THE COLLEGE OF THE BAHAMAS

EXAMINATION

SEMESTER 01-2012

FACULTY OF PURE AND APPLIED SCIENCES

SCHOOL OF CHEMISTRY, ENVIRONMENTAL & LIFE SCIENCES

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DATE AND TIME OF EXAMINATION: 9:00 am Monday 23rd April 2012 in rooms F1, F2 and F3
DURATION: 3 HOURS

COURSE NUMBER: CHEM 225

COURSE TITLE: COLLEGE CHEMISTRY II

STUDENT NAME:

STUDENT NUMBER:

LECTURER'S NAME

INSTRUCTIONS TO CANDIDATES: This paper has 14 pages and 3 sections. Please follow the instructions given with each section. There is a total of 100 marks for the paper.

Information for students

PV=nRT
R=0.0821 L atm $mol^{-1}K^{-1}$ = 8.31 J mol^{-1} K^{-1} = 8.31 Pa m^3 mol^{-1} K^{-1}
Avogadro's number, L = $6.02\times10^{23}mol^{-1}$
Faraday's constant, F = 96 500 C mol^{-1}

PERIODIC TABLE OF THE ELEMENTS

←Periods→	I	II	← Groups →									III	IV	V	VI	VII	0
1	1 H hydrogen 1.0																2 He helium 4.0
2	3 Li lithium 6.9	4 Be beryllium 9.0										5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
3	11 Na sodium 23.0	12 Mg magnesium 24.3										13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
4	19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
5	37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium 98.9	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd paladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
6	55 Cs cesium 132.9	56 Ba barium 137.3	57 La lanthanum 138.9	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.85	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium	85 At astatine	86 Rn radon
7	87 Fr francium	88 Ra radium	89 Ac actinium															

Key: 19 ← proton number; K ← symbol of element; potassium ← name of element; 39.1 ← relative atomic mass

Lanthanides:

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
cerium 140.1	praseodymium 140.9	neodymium 144.2	promethium	samarium 150.4	europium 152.0	gadolinium 157.3	terbium 158.9	dysprosium 162.5	holmium 164.9	erbium 167.3	thulium 168.9	ytterbium 173.0	lutetium 175.0

Actinides:

90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	06 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr
thorium 232.0	protoactinium 231.0	uranium 238.0	neptunium 237.0	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendelevium	nobelium	lawrencium

Note: relative atomic masses are omitted for highly unstable elements.

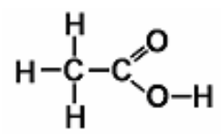
SECTION I: Multiple Choice Questions

Select the SINGLE best alternative in each of the following cases and indicate your answer by marking the corresponding letter on the answer sheet provided. You may place any working on these pages if you wish. It will not be considered during marking.
Do not spend more than 1½ minutes on any question in this section: if the question takes more time, guess the answer and mark the question for later consideration if time allows.
There is a total of 40 marks for this section.

Questions 1) and 2) concern various acids. Using the rules that relate acid strength to structure, pick the strongest acid in each case.

1) **A** $HClO$ **B** $HClO_2$ **C** $HClO_3$
D $HClO_4$ **E** $HBrO$

2) **A**



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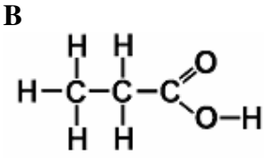

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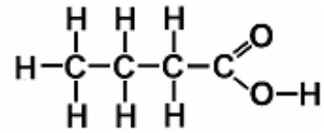

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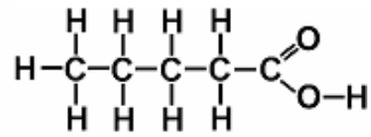
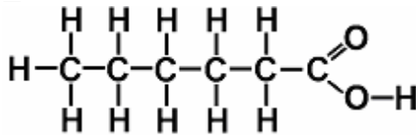
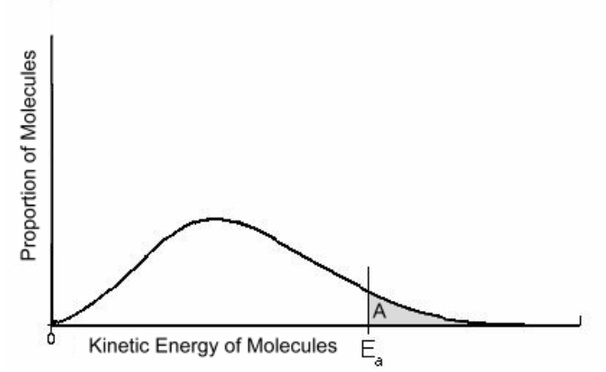


E



Questions 3) and 4) involve the following graph showing the kinetic energy of the molecules involved in a reaction:



3) The area A represents the proportion of:
A molecules with at least the activation energy.
B molecules with exactly the activation energy.
C molecules with less than the activation energy.
D slow-moving molecules.
E average-speed molecules.

4) Upon the introduction of a catalyst, the shaded area A
A is increased.
B is decreased.
C is unaffected
D is increased by homogeneous catalysts only.
E is decreased by heterogeneous catalyst only.

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5) The reaction between propanone and iodine in acidified aqueous solution is described by the following equation:

$$CH_3COCH_3(aq) + I_2(aq) + H^+(aq) \xrightarrow{\text{propanone}} CH_2ICOCH_3(aq) + 2H^+(aq) + I^-(aq)$$

The reaction is also found to be first order with respect to both propanone and hydrogen ion, but zero order with respect to iodine. If the concentration of the reactants is doubled, the rate is
A doubled.
B tripled.
C quadrupled.
D multiplied by ½.
E multiplied by ¼.

6) The rate of a chemical reaction depends strongly on temperature. Which statement best explains this observation?
A At high temperatures the activation energy of the reaction is lower.
B At high temperatures almost all molecules are present as activated complexes.
C At high temperatures the concentrations of reactants is higher.
D At high temperatures the partial pressures of the reactants are higher.
E At high temperatures a much larger proportion of molecules have sufficient energy to react.

7) Solutions of magnesium sulphate in water are weakly acidic because:
A Water molecules bound to the magnesium ion lose protons more readily than free water molecules.
B Sulphuric acid is not a very strong acid.
C The second proton of sulphuric acid is lost with some difficulty.
D Magnesium ions react readily with protons.
E Such solutions are usually impure.

8) The K_b value for a certain base X^- is 10^{-6} at 25°C. The K_a value for HX at the same temperature is therefore:
   A 10^{-8}
   B 10^{-6}
   C 10^{6}
   D 10^{8}
   E 6

9) The decomposition of dinitrogen pentoxide in tetrachloromethane solution (tcm) may be represented by the equation:
   $2N_2O_5(tcm) \rightarrow 4NO_2(tcm) + O_2(g)$
   The nitrogen dioxide is soluble in tetrachloromethane whilst the oxygen is not. Measurement of which physical property could most easily be used for determining the rate of this reaction?
   A Electrical conductivity of the solution.
   B Volume of oxygen evolved.
   C pH of the solution.
   D Total mass of reactants and products.
   E Volume of the solution.

10) The experimentally determined rate equation for the reaction represented by the equation:
   $BrO_3^-(aq) + 5Br^-(aq) + 6H^+(aq) \rightarrow 3Br_2(aq) + 3H_2O(aq)$
   is $rate = k[BrO_3^-][Br^-][H^+]^2$
   The units of the rate constant are:
   A Ms^{-1}
   B s^{-1}
   C $M^{-1}s^{-1}$
   D $M^{-2}s^{-1}$
   E $M^{-3}s^{-1}$

11) At a certain temperature the partial pressures of carbon monoxide, chlorine and carbon oxide dichloride in the equilibrium mixture defined by the equation:
   $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$
   carbon oxide dichloride
   were 2, 4 and 48 atm respectively. What is the value of K_p?
   A 0.167
   B 6
   C 24
   D 54
   E 86

12) Consider the following system at equilibrium:
   $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g) \quad \Delta H$ +ve
   Which operation would displace the equilibrium position to the right?
   A Adding more $CaCO_3$ to the system.
   B Adding more CaO to the system.
   C Increasing the partial pressure of CO_2.
   D Heating the system.
   E Adding an inert gas at constant volume. (Assume ideal behaviour.)

13) Which one of the following changes the value of the ***equilibrium constant*** for a reaction?
   A Reducing the pressure of the reaction mixture.
   B Increasing the volume of the reaction mixture.
   C Increasing the concentration of reactants.
   D Reducing the temperature of the system.
   E Removing one of the products.

14) Given that the K_a values of the following five acids decrease in the order: HI > HCl > C_6H_5COOH > CH_3COOH > HPO_4^{2-}, which salt is expected to give the highest pH value when in 0.1 M solution?
   A NaCl
   B NaI
   C C_6H_5COONa
   D CH_3COONa
   E Na_3PO_4

15) Which statement regarding the ionic product of water (K_w) is **NOT** true?
   A K_w is the equilibrium constant for the reaction:
   $2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$
   B K_w is decreased by the addition of an acid to an aqueous solution.
   C K_w is altered by a change in temperature.
   D K_w is constant for any dilute aqueous solution at constant temperature.
   E K_w is approximately 10^{-14} at 25°C.

16) A certain weak monoprotic acid has a pK_a value of 4.8. What is the pH of a buffer solution containing 0.2 mol of the weak acid, together with 0.2 mol of the sodium salt of the acid, all dissolved in $250cm^3$ of water?
   A 2.8
   B 3.8
   C 4.8
   D 5.8
   E 6.8

17) Which statement regarding a 10^{-8}M solution of hydrochloric acid in water is correct?
   A The solution is a buffer solution.
   B The solution has a pH of 8.
   C Such a solution cannot be prepared.
   D The solution is very slightly acidic.
   E The solution is extremely acidic.

18) Which one of the following pairs of species is an acid-base conjugate pair?
   A H_3O^+ and OH^-
   B $CH_3NH_4^+$ and CH_3NH_2
   C $H_2PO_4^-$ and HPO_4^{2-}
   D H_3PO_4 and PO_4^{3-}
   E CO_2 and H_2CO_3

19) Which one of the following is **NOT** a redox reaction?
   A $SO_2 + OH^- \rightarrow HSO_3^-$
   B $2Na + Cl_2 \rightarrow 2NaCl$
   C $2Mg + O_2 \rightarrow 2MgO$
   D $SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$
   E $Fe + Cu^{2+} \rightarrow Cu + Fe^{2+}$

20) Phenolphthalein is a better indicator for the titration of ethanoic acid with sodium hydroxide solution than is methyl orange. Which statement is the best explanation for this?
A Phenolphthalein gives a more vivid colour change than does methyl orange.
B Phenolphthalein changes colour in slightly alkaline solution.
C Phenolphthalein changes colour in slightly acidic solution.
D Methyl orange would not change colour during this titration.
E Methyl orange changes colour over a much greater pH range than does phenolphthalein.

21) $H_2PO_4^-$ has $pK_a = 7.2$ and $pK_b = 11.9$. A solution of NaH_2PO_4 is therefore:
A Strongly basic.
B Weakly basic.
C Neutral.
D Weakly acidic.
E Strongly acidic.

22) The following equilibrium is established when solid lead(II) chloride is shaken with water:
$PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq)$
If K_{sp} is the solubility product of lead chloride at 25°C, and the solubility of lead chloride is *x* mol dm^{-3} at this temperature, then:
A $K_{sp} = 2x^2$
B $K_{sp} = x^2$
C $K_{sp} = 2x^3$
D $K_{sp} = 4x^3$
E $K_{sp} = 27x^4$

23) Which equation shows nitric acid acting as an oxidizing agent?
A $P_4O_{10} + 4HNO_3 \rightarrow 4HPO_3 + 2N_2O_5$
B $6Fe^{2+} + 8HNO_3 \rightarrow 6Fe^{3+} + 2NO + 4H_2O + 6NO_3^-$
C $CO_3^{2-} + 2HNO_3 \rightarrow CO_2 + H_2O + 2NO_3^-$
D $HNO_3 + NaCl \rightarrow NaNO_3 + HCl$
E $2HNO_3 + Na_2SO_3 \rightarrow 2NaNO_3 + SO_2 + H_2O$

24) Given the equations:
$S_2O_8^{2-} + 2e^- \rightarrow 2SO_4^{2-}$
$Mn^{2+} + 4H_2O \rightarrow MnO_4^- + 8H^+ + 5e^-$
which figure expresses the correct number of moles of $S_2O_8^{2-}$ ions required to oxidize 1 mole of Mn^{2+} ions?
A 0.4
B 0.5
C 1.0
D 2.0
E 2.5

25) In which compound is the oxidation number of vanadium equal to +3?
A VCl_4
B H_3VO_4
C $H_4V_2O_7$
D NH_4VO_3
E K_3VF_6

26) The e.m.f. of the cell:
$Pt \mid H_2(g) \mid HCl(aq) \parallel CuSO_4(aq) \mid Cu$
is **INDEPENDENT** of which one of the following?
A temperature
B concentration of hydrochloric acid
C concentration of copper(II) sulphate solution
D mass of the platinum electrode
E pressure of hydrogen

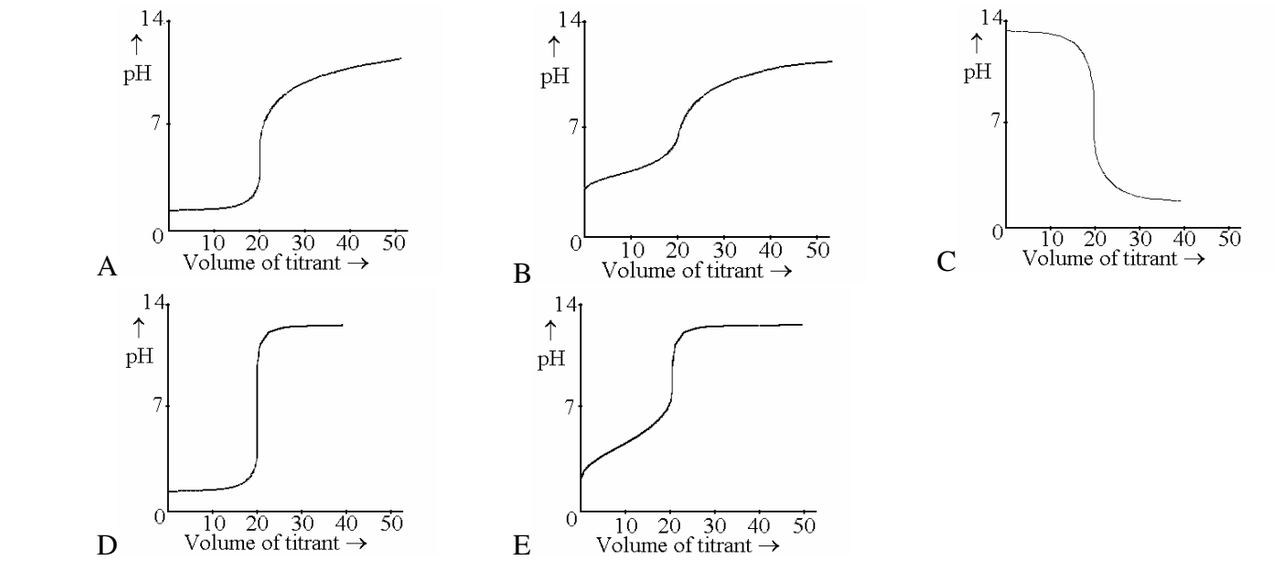
27) Standard electrode potentials for the gain of one electron by the ions $Cu^+(aq)$ and $Cu^{2+}(aq)$ are as follows:
$Cu^+(aq) + e^- \rightarrow Cu(s)$ $\quad E^\ominus = +0.52v$
$Cu^{2+}(aq) + e^- \rightarrow Cu^+(aq)$ $\quad E^\ominus = +0.17v$
The standard electrode potential in volts for the reaction:
$2Cu^+(aq) \rightarrow Cu^{2+}(aq) + Cu(s)$ is:
A -0.69
B -0.35
C +0.52
D +0.69
E +0.35

28) The equilibrium constant for the reaction
$A(aq) \rightleftharpoons B(aq)$ is 3.75×10^{-7}.
Which statement is **TRUE**?
A The equilibrium concentration of A is less than that of B.
B The equilibrium concentration of A is greater than that of B.
C Adding a suitable catalyst will increase the equilibrium concentration of A.
D Adding a catalyst will increase the value of the equilibrium constant.
E Adding more A will increase the value of the equilibrium constant.

29) Consider the reaction
$NO(g) + O_3(g) \rightleftharpoons NO_2(g) + O_2(g)$
The activation energy for this reaction is 10 kJ, whilst the activation energy for the reverse reaction is 210 kJ. What is the enthalpy change for the forward reaction, in kJ?
A -200
B -210
C -220
D -2000
E -20

30) For the reaction
$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
the average rate with respect to the production of ammonia is expressed as
$$\frac{\Delta[NH_3]}{\Delta t}$$
An expression whose value is the same is:
A $\frac{-\Delta[N_2]}{\Delta t}$ B $\frac{\Delta[H_2]}{2\Delta t}$
C $\frac{\Delta[N_2]}{\Delta t}$ D $\frac{\Delta[H_2]}{3\Delta t}$
E $\frac{-2\Delta[N_2]}{\Delta t}$

Questions 31) -35). The diagrams A to E represent titration curves for the reaction between various acids and bases.



Given that each curve may be used once, more than once or not at all, choose from A to E the curve which best represents

31) the titration of 20 cm^3 of 0.1M HCl with 0.1M NaOH.
32) the titration of 20 cm^3 of 0.1M CH_3COOH with 0.1M NaOH.
33) the titration of 20 cm^3 of 0.1M CH_3COOH with 0.1M NH_3.
34) the titration of 20 cm^3 of 0.1M NaOH with 0.1M HCl.
35) the titration of 20 cm^3 of 0.1M HCl with 0.1M NH_3.

Questions 36) to 40) concern the following experimental situation.

Six equilibrium mixtures *(1)* were made up with various volumes of 0.10 M $Fe(NO_3)_2$ solution, dilute HNO_3(aq) and 0.10 M $AgNO_3$ (aq). The solutions were stirred for 15 minutes until a precipitate *(2)* formed, and then filtered into separate test tubes. 5.00 cm^3 aliquots were each mixed with about 1 cm^3 of 1 M $Fe(NO_3)_3$ *(3)* and titrated *(4)* with 0.010 M KSCN(aq). The titre values were used to calculate the concentrations of the various species present at equilibrium and hence the equilibrium constant.

36) The equilibrium studied, referred to in *(1)*, involves an equilibrium between
- A NO_3^- ions, H_3O^+ ions and HNO_3 molecules.
- B Fe^{3+} ions, SCN^- ions and $[FeSCN]^{2+}$ complex.
- C Fe^{2+} ions, Ag^+ ions, Fe^{3+} ions and solid Ag.
- D Fe^{3+} ions and Fe^{2+} ions.
- E Ag^+ ions, Fe^{2+} ions, NO_3^- ions and Ag.

37) Precipitate *(2)* was
- A $AgNO_3$
- B AgCl
- C AgSCN
- D Ag
- E $Fe(SCN)_3$

38) The $Fe(NO_3)_3$ *(3)* was added in order to
- A oxidise any silver still present to silver ions.
- B react with excess thiocyanate ions to form a coloured complex.
- C catalyse the reaction between titrant and titrand in (4).
- D prevent the forward reaction in the equilibrium from occurring.
- E prevent the precipitation of silver thiocyanate.

39) The precipitate *(2)* was filtered off in order to
- A prevent the equilibrium concentration of silver ions from changing during the titration *(4)*.
- B make the solution clear so that the end-point in *(4)* could be seen more clearly.
- C prevent solid matter interfering with the equilibrium reactions.
- D remove excess Ag^+ ions from the solution.
- E collect it for weighing.

40) Dilute HNO_3 is added to:
- A Form a complex with the silver ion.
- B Act as an indicator
- C Lower the pH at the end-point.
- D Displace equilibrium to the right.
- E Suppress hydrolysis of the hydrated Fe^{3+} ion.

SECTION II

Answer all questions in this section in the spaces provided on the question paper. Numerical answers must be supported by working, and, where appropriate, must be displayed to the correct number of significant figures or decimal places. Underline your final answers.
There are 32 marks for this section.

1) This question concerns oxidation and reduction. (Total marks: 8)
The balanced half-reaction for the reduction of $X_2O_7^{m-}(aq)$ to $X^{3+}(aq)$ (X represents an element, and m an integer) in acidified aqueous solution is

$$X_2O_7^{m-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2X^{3+}(aq) + 7H_2O(l)$$

a) Determine the value of m. Explain your reasoning. (3 marks)

b) Deduce the overall balanced net ionic equation for the reaction in which potassium chlorate, $KClO_3(aq)$, oxidizes $Mn^{2+}(aq)$ to $MnO_2(s)$ in acid solution. The chlorate ion is reduced to chlorine gas. (5 marks)

2) Fill in the blanks in the following table with the appropriate hydrolysis reaction. (8 marks)

Salt	**Acid/base properties of aqueous solution**	**Hydrolysis equation**
$KHCO_3$	basic	
KCN	basic	
$Al(NO_3)_2$	acidic	
NH_4NO_3	acidic	

3) The following question deals with chemical equilibrium. (Total marks = 16)

A student studied the following equilibrium system

$$\underset{\text{pale yellow}}{Fe^{3+}(aq)} + \underset{\text{colourless}}{SCN^{-}(aq)} \rightleftharpoons \underset{\text{reddish brown}}{FeSCN^{2+}(aq)}$$

which she made up by mixing 20.0 cm^3 of 0.100 M $Fe(NO_3)_3(aq)$ with 20.0 cm^3 of 0.100 M KSCN(aq) diluted to 1.00 L with distilled water.

a) What is the initial concentration (in mol dm^{-3}) of the Fe^{3+} and SCN^- in the mixture of solutions? (1 mark)

b) Is the equilibrium of a heterogeneous or homogeneous type? (1 mark)

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c) Write the expression for the equilibrium constant. (1 mark)

d) Calculate the concentration of the complex ($FeSCN^{2+}$)at equilibrium, given that the equilibrium constant for the above reaction is 891 at the temperature of the mixture. (3 marks)

e) Write a net ionic equation describing the formation of a precipitate when sodium hydroxide is added to the equilibrium mixture. (1 mark)

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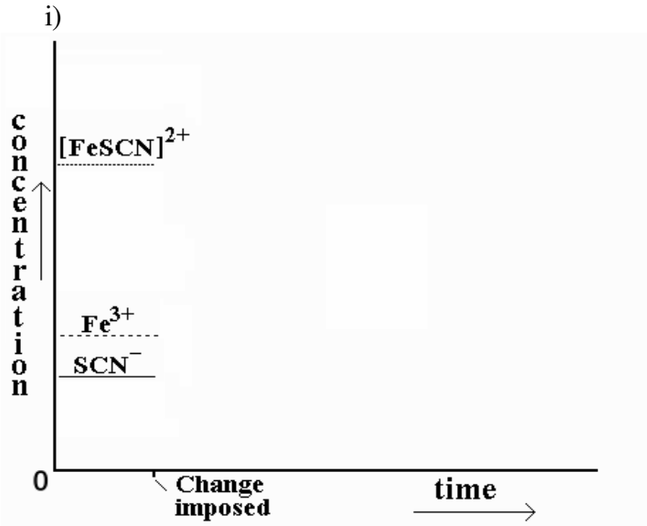
f) What colour change occurs to the remaining *solution* (the *supernatant*) as a result of adding the sodium hydroxide?

(1 mark)

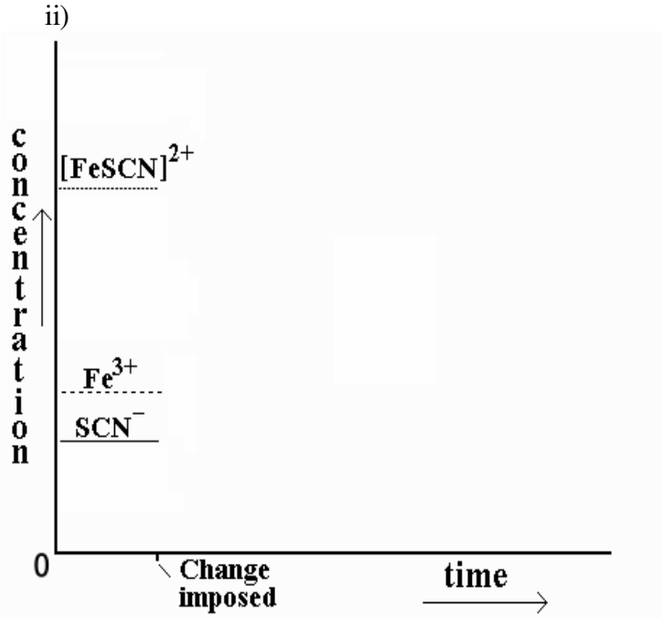
g) Explain the colour change in f) above by referring to Le Chatelier's principle. (2 marks)

h) Given that the reaction $Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons FeSCN^{2+}(aq)$ is exothermic, complete the graphs below to show the effect of (i) increasing the concentration of SCN^{-} and (ii) increasing the temperature of the solution, on the equilibrium system. Assume the imposed changes occur instantaneously. (6 marks)

i)



ii)



SECTION III

Students' Choice

Answer TWO questions from this section in the spaces provided on the question paper. If more than two questions are answered, only the first two will be marked!

Numerical answers must be supported by working, and, where appropriate, must include units and be displayed to the correct number of significant figures or decimal places. Underline your final answers. There is a total of 28 marks for this section.

1) The following electrochemical cell is constructed at 25°C:

$$Cu(s)\,|\,Cu^{2+}(aq,\ 1\ M)\,\|\,H^{+}(aq,1\ M)\,|\,H_2(g,1\ atm)\,|\,Pt(s)$$

The standard reduction potential for the $Cu^{2+}\,|\,Cu$ couple is +0.34 v. (Total marks = 14)

a) Write down the chemical equation which corresponds to the cell notation above. (1 mark)

b) Calculate the standard e.m.f. for the cell and deduce which way the above equation will proceed spontaneously. (2 marks)

c) Define the term "cathode". Which half-cell contains the cathode if the reaction of part (a) goes left to right. (2 marks)

d) Calculate the pH of the solution in the half-cell on the right. (2 marks)

e) Explain how the pH changes in the right-hand half cell as current is draw from the cell. (2 marks)

f) What does the double vertical line in the cell-notation indicate? Mention one function of this part of the cell. (2 marks)

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g) If the concentration of H^+ in the right-hand half-cell is maintained at exactly 1 M, and the supply of copper and hydrogen gas (at 1 atm) is likewise maintained constant, what is the molarity of the Cu^{2+} in the left-hand half-cell when the cell e.m.f. has declined to zero? You may use the Nernst equation,

$$E = E^\circ - \frac{RT}{nF} \ln Q$$ (3 marks)

2) This question concerns the properties of acids and bases. (Total marks = 14)

a) Hypochlorous acid (HOCl) is a weak monobasic acid whose K_a value at 25°C is 2.88×10^{-8}.

i) By drawing up the "ICE" table, find the pH of a 0.025 M solution of HOCl at 25°C. (6 marks)

ii) How many moles of NaOCl should be added to 800cm^3 of 2.0×10^{-2}M HOCl in order to obtain a solution of pH 7.0, assuming no change in volume? (Na = 23.0, O = 16.0, Cl = 35.5). You may use the buffer equation.

$$pH = pK_a + \log\frac{C_b}{C_a}$$ (5 marks)

iii) At what pH value would an NaOCl/HOCl buffer achieve its maximum buffer capacity? (1 mark)

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b) The pH of a 0.10M solution of sodium carbonate (Na_2CO_3) is 11.65 at 25°C. Calculate the concentration of the hydroxide ion. (2 marks)

3) This question concerns the reaction

$$2NO(g) + H_2(g) \rightarrow N_2O(g) + H_2O(g)$$

for which the following experimental rate data were collected in three experiments carried out at the same temperature. (Total marks = 14)

Experiment Number	INITIAL [NO] /M	INITIAL [H_2] /M	INITIAL RATE OF N_2O FORMATION /M min^{-1}
1	0·60	0·37	0·18
2	1·80	0·37	1.62
3	1·80	1·11	4·86

a) Derive the rate law for the reaction showing your reasoning. (3 marks)

b) Calculate the rate constant for the reaction. (2 marks)

c) Calculate the initial rate of formation of N_2O when the concentration of NO is 0.70 M, and the concentration of H_2 is 0.50 M. (2 marks)

d) Calculate the initial rate of formation of N_2O when the initial rate of consumption of NO is 2.16 M min^{-1}.

(2 marks)

e) The following mechanism is proposed for the above reaction:

$NO + H_2 \rightarrow NOH_2$ Slow step A

$NOH_2 + NO \rightarrow N_2O + H_2O$ Fast step B

i) Identify the rate-determining step. (1 mark)

ii) Write the rate law implied by the mechanism. (1 mark)

iii) By referring to part (a) above, explain why the proposed mechanism cannot be correct. (1 mark)

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iv) Describe what you would need to measure, and what factor(s) would need to be kept constant, to find the activation energy of the reaction. (2 marks)

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