Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Teacher's Use	
Section	Mark
Task	
Section A	
Section B	
TOTAL ISA Mark	

General Certificate of Education
Advanced Level Examination
June 2010

Chemistry CHM6T/Q10/test

Unit 6T A2 Investigative Skills Assignment

Written Test

For submission by 15 May 2010

For this paper you must have:
- the Periodic Table/Data Sheet, provided at the end of this paper
- the task sheet and your Candidate Results Sheet
- a ruler with millimetre measurements
- a calculator.

Time allowed
- 1 hour

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 30.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use accurate scientific terminology.

Signature of Teacher marking the ISA ..... Date .....

Do not write outside the box

Section A

These questions are about the task, the investigation of a rust remover.

You should use your Task Sheet and your Candidate Results Sheet to answer them.

Answer **all** questions in the spaces provided.

1 Record the average titre from your Candidate Results Sheet.

Average titre / cm^3 .....

(1 mark)

2 Half-equations for the redox reactions occurring in the reaction between ethanedioic acid and potassium manganate(VII) in acidic solution are shown below.

$$H_2C_2O_4 \longrightarrow 2CO_2 + 2H^+ + 2e^-$$

$$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$$

Deduce an overall equation for the reaction between ethanedioic acid and manganate(VII) ions in acidic solution.

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(1 mark)

3 The concentration of the potassium manganate(VII) used was 0.0200 mol dm^{-3}. Use your answers from Questions **1** and **2** to calculate the amount, in moles, of ethanedioic acid in 25.0 cm^3 of the rust remover solution. Show your working.

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(2 marks)

Do not write outside the box

4 Use your answer from Question **3** to calculate the concentration, in mol dm^{-3}, of ethanedioic acid in the rust remover solution.

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(1 mark)

5 The rust remover solution was prepared by dissolving 6.00 g of the acid supplied by the manufacturer in water and making up to 1.00 dm^3 of solution. Use your answer from Question **4** to calculate the M_r of the acid. Assume that the solution is made from a pure sample of the acid.

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(1 mark)

6 Use data from the Periodic Table to calculate the M_r of ethanedioic acid dihydrate $H_2C_2O_4.2H_2O$

Give your answer to the appropriate precision.

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(1 mark)

7 Can you use your answers from Questions **5** and **6** to identify the form of ethanedioic acid in the rust remover? Explain your answer.

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(1 mark)

Turn over for the next question

Do not write outside the box

8 For the pipette and the burette, the maximum total errors are shown below. These errors take into account multiple measurements.

pipette	± 0.05 cm^3
burette	± 0.15 cm^3

Estimate the maximum percentage error in using these pieces of apparatus, and hence calculate the maximum overall percentage error. Use the average titre from Question **1** to calculate the percentage error in using the burette. Show your working.

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(2 marks)

9 Ethanedioic acid is toxic. Suggest **one** safety precaution you would take to minimise this hazard.

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(1 mark)

10 State why the M_r of a compound may be insufficient on its own to identify the compound.

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(1 mark)

12

Do not write outside the box

Section B

Answer **all** questions in the spaces provided.

Introduction

In **Section A** you determined the M_r of the ethanedioic acid present in a rust remover. Ethanedioic acid is an important industrial chemical with a number of uses.

11 Ethanedioate ions, $C_2O_4^{2-}$, act as bidentate ligands with transition metal ions.

11 (a) Write an equation for the ligand substitution reaction of an excess of ethanedioate ions with aqueous cobalt(II) ions.

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(1 mark)

11 (b) The table below shows some standard electrode potentials.

		$E^{\ominus}$/V
$Fe^{3+}(aq) + e^-$	$\longrightarrow Fe^{2+}(aq)$	+0.77
$2CO_2(g) + 2e^-$	$\longrightarrow C_2O_4^{2-}(aq)$	–0.49

Use $E^{\ominus}$ values from the table to explain why an iron(III) complex is **not** formed when solutions containing ethanedioate ions and iron(III) ions are mixed.

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(2 marks)

Turn over for the next question

Do not write outside the box

12 When a solution containing iron(II) ions is treated with a slight excess of a solution containing ethanedioate ions a bright yellow precipitate of hydrated iron(II) ethanedioate, $FeC_2O_4.2H_2O$, is formed. The precipitate is filtered off, washed with propanone and then allowed to dry. A typical yield of the solid is 95%.

12 (a) Propanone boils at 56 ºC and is miscible with water in all proportions. Suggest **two** reasons why washing with propanone is an effective method for producing a pure, dry precipitate.

Reason 1 .....

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Reason 2 .....

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(2 marks)

12 (b) By suggesting a simple test tube reaction, state how the filtrate could be tested to show that all of the iron(II) ions have been removed from the solution. State what you would observe.

Test .....

Observation .....

(2 marks)

12 (c) Suggest **one** reason why the typical yield of iron(II) ethanedioate is less than 100%.

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(1 mark)

12 (d) Calculate the mass of hydrated iron(II) ethanedioate, $FeC_2O_4.2H_2O$ that can be formed from 50.0 cm^3 of a 0.50 mol dm^{-3} solution of iron(II) sulfate when the yield of the reaction is 95%. Show your working.

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(3 marks)

Do not write outside the box

12 (e) The identity of the precipitate can be confirmed by dissolving it in sulfuric acid and titrating the mixture with potassium manganate(VII).

12 (e) (i) Use the half-equations given in Questions **2** and **11 (b)** to deduce an overall equation for the reaction between iron(II) ions and manganate(VII) ions in acidic solution.

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(1 mark)

12 (e) (ii) Deduce the number of moles of iron(II) ethanedioate that would react with one mole of potassium manganate(VII) in acidic solution.

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(1 mark)

13 Ethanedioate ions can be used to remove calcium ions from blood plasma.
A precipitate of calcium ethanedioate is formed. Write an ionic equation for the reaction of ethanedioate ions with calcium ions.

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(1 mark)

14 Ethanedioic acid is used to clean marble, a form of calcium carbonate. Suggest **one** reason why the reaction between ethanedioic acid and marble stops after a short time.

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(1 mark)

15 Tea leaves contain ethanedioic acid. Suggest **one** reason why tea drinkers do **not** suffer from ethanedioic acid poisoning.

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(1 mark)

Do not write outside the box

16 Ethanedioic acid is produced by the oxidation of carbon monoxide in a multi-step process. The equation which summarises the reactions taking place is shown below.

$$4CO + 4NaOH + O_2 + 4HCl \longrightarrow 2H_2C_2O_4 + 4NaCl + 2H_2O$$

Calculate the percentage atom economy for the formation of ethanedioic acid in this reaction. Show your working.

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(2 marks)

18

END OF QUESTIONS

Table 1

Infrared absorption data

Bond	Wavenumber /cm^{-1}
N—H (amines)	3300 – 3500
O—H (alcohols)	3230 – 3550
C—H	2850 – 3300
O—H (acids)	2500 – 3000
C≡N	2220 – 2260
C=O	1680 – 1750
C=C	1620 – 1680
C—O	1000 – 1300
C—C	750 – 1100

Table 2

^{1}H n.m.r. chemical shift data

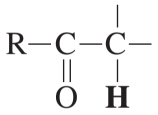
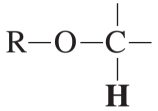
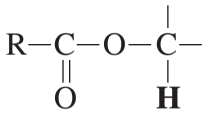
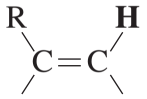
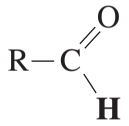
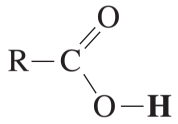
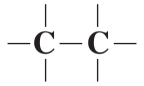
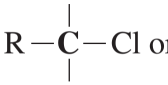
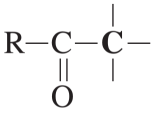
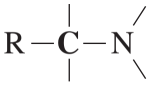
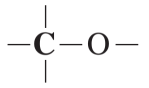
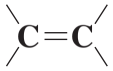
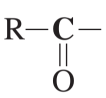
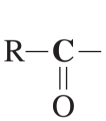
Type of proton	δ/ppm
ROH	0.5 – 5.0
RCH_3	0.7 – 1.2
RNH_2	1.0 – 4.5
R_2CH_2	1.2 – 1.4
R_3CH	1.4 – 1.6
	2.1 – 2.6
	3.1 – 3.9
RCH_2Cl or Br	3.1 – 4.2
	3.7 – 4.1
	4.5 – 6.0
	9.0 – 10.0
	10.0 – 12.0

Table 3

^{13}C n.m.r. chemical shift data

Type of carbon	δ/ppm
	5 – 40
 Cl or Br	10 – 70
	20 – 50
	25 – 60
 alcohols, ethers or esters	50 – 90
	90 – 150
	110 – 125
	110 – 160
 esters or acids	160 – 185
 aldehydes or ketones	190 – 220

The Periodic Table of the Elements

1	2											3	4	5	6	7	0
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	96.0 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La * lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac † actinium 89	[267] Rf rutherfordium 104	[268] Db dubnium 105	[271] Sg seaborgium 106	[272] Bh bohrium 107	[270] Hs hassium 108	[276] Mt meitnerium 109	[281] Ds darmstadtium 110	[280] Rg roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

140.1 Ce cerium 58	140.9 Pr praseodymium 59	144.2 Nd neodymium 60	[145] Pm promethium 61	150.4 Sm samarium 62	152.0 Eu europium 63	157.3 Gd gadolinium 64	158.9 Tb terbium 65	162.5 Dy dysprosium 66	164.9 Ho holmium 67	167.3 Er erbium 68	168.9 Tm thulium 69	173.1 Yb ytterbium 70	175.0 Lu lutetium 71
232.0 Th thorium 90	231.0 Pa protactinium 91	238.0 U uranium 92	[237] Np neptunium 93	[244] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[247] Bk berkelium 97	[251] Cf californium 98	[252] Es einsteinium 99	[257] Fm fermium 100	[258] Md mendelevium 101	[259] No nobelium 102	[262] Lr lawrencium 103

* **58 – 71** Lanthanides

† **90 – 103** Actinides

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