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/P10/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 an organic compound.

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

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

1 Deduce a possible identity for **X**. Explain your deduction.

Identity for **X** ....

Explanation ....

....

....

(2 marks)

2 State how the sample labelled **X** could be tested to show whether it is contaminated with hydrogen iodide used in the manufacturing process.

Test ....

Observation ....

(2 marks)

3 Small amounts of the esters methyl ethanoate and methyl methanoate are also formed in this manufacturing process. Identify the **two** substances in the reaction mixture that would react to form methyl methanoate. Write an equation for this reaction to form methyl methanoate.

Substances ....

Equation ....

(2 marks)

Do not write outside the box

4 Infrared spectroscopy can be used to distinguish between esters, alcohols and carboxylic acids.

Use **Table 1** on the Data Sheet, where appropriate, to answer the following questions.

4 (a) Identify an absorption that would enable you to distinguish between methyl ethanoate and ethanoic acid.

....

(1 mark)

4 (b) Identify an absorption that would enable you to distinguish between methanol and ethanoic acid.

....

(1 mark)

4 (c) State how infrared spectroscopy can be used to show that an unknown ester is definitely methyl ethanoate.

....

....

....

....

(2 marks)

10

Turn over for the next question

Turn over ▶

Section B

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

Introduction

Ethanoic acid is manufactured in industry from methanol and carbon monoxide in a multi-step process involving hydrogen iodide. Ethanoic acid is obtained from the reaction mixture by fractional distillation. Methanoic acid is a useful by-product of this process.

The K_a value of an organic acid can be determined by using the pH curve obtained when the acid is titrated against sodium hydroxide. The pH of the solution formed when exactly half of the acid has been neutralised is equal to the pK_a value of the acid. The K_a value of the acid can be used to confirm its identity.

A chemist used a pH curve to determine the pK_a value of acid **Y**, formed during the manufacture of ethanoic acid. The chemist transferred 25.0 cm^3 of a solution of acid **Y** into a beaker using a pipette, and measured the pH of the acid solution using a pH meter which could be read to one decimal place. A solution of sodium hydroxide of concentration 0.100 mol dm^{-3} was added from a burette in small portions. The pH of the mixture was recorded after each addition of the sodium hydroxide solution. The chemist's results are given in the table below.

Volume of sodium hydroxide solution added / cm^3	pH
0.0	3.0
2.0	3.4
4.0	3.5
8.0	3.7
12.0	4.3
16.0	4.1
20.0	4.3
22.0	4.7

Volume of sodium hydroxide solution added / cm^3	pH
23.5	5.1
24.0	5.5
24.5	11.8
25.0	12.1
26.0	12.3
27.0	12.4
28.0	12.5
30.0	12.5

5 Use the results given in the table above to plot a graph of pH (*y*-axis) against volume of sodium hydroxide solution added. Use the points to draw the pH curve, ignoring any anomalous results. *(6 marks)*

6 Use your graph from Question **5** to determine the

6 (a) volume of sodium hydroxide solution at the end-point of the titration .... cm^3

6 (b) volume of sodium hydroxide solution needed to neutralise half the acid .... cm^3

6 (c) pH of the half-neutralised mixture. Give your answer to one decimal place. ....

(3 marks)

7 Use the pH of the half-neutralised mixture from Question **6 (c)** to calculate the value of the acid dissociation constant, K_a, of the acid **Y**. Show your working.

....

....

....

....

(2 marks)

8 The table below shows the K_a values for some organic acids.

Acid	K_a / mol dm^{-3}
Methanoic acid	1.6×10^{-4}
Ethanoic acid	1.7×10^{-5}
Iodoethanoic acid	6.8×10^{-4}
Propanoic acid	1.3×10^{-5}

Use your answer from Question **7** to identify acid **Y** from this table.

....

(1 mark)

9 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 percentage error in using each of these pieces of apparatus. You should use your answer to Question **6 (a)** to estimate the percentage error in using the burette.

....

....

....

(1 mark)

10 Calculate the difference between the K_a value from Question **7** and the K_a value of the acid you identified as the acid **Y** in the table in Question **8**.

Express this difference as a percentage of the value given in the table in Question **8**. (If you could not complete the calculation in Question **7**, you should assume that the K_a value determined from the graph is 1.9×10^{-4} mol dm^{-3}. This is not the correct value.)

....

....

(1 mark)

11 Other than by using a different pH meter, state **one** way in which the accuracy of the pH readings could be improved.

....

....

(1 mark)

12 State why there was little change in the pH value of the mixture when between 8 cm^3 and 20 cm^3 of alkali were added.

....

(1 mark)

13 Methanoic acid is used to remove the oxide coating from magnesium before the metal is used to make alloys.

13 (a) Write an equation for the reaction of methanoic acid and magnesium oxide to form magnesium methanoate and water.

....

(1 mark)

13 (b) Suggest **one** reason why methanoic acid is used in preference to the cheaper sulfuric acid.

....

....

(1 mark)

14 Methanoic acid can also be formed by the reaction of hydrogen and carbon dioxide. The equation for this reaction is shown below.

$$H_2 + CO_2 \rightleftharpoons HCOOH$$

14 (a) The combustion of methanoic acid has been suggested as a possible source of clean energy in the future. Suggest why this use of methanoic acid as a fuel can be considered to be carbon neutral.

....

....

(1 mark)

14 (b) Methanoic acid has also been suggested as a starting material in the manufacture of polymers. State **one** advantage, other than cost, of using methanoic acid rather than a starting material obtained from crude oil.

....

....

(1 mark)

20

END OF QUESTIONS

GCE Chemistry Data Sheet

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
RO**H**	0.5–5.0
RC**H**$_3$	0.7–1.2
RN**H**$_2$	1.0–4.5
R_2C**H**$_2$	1.2–1.4
R_3C**H**	1.4–1.6
R–C(=O)–C–**H**	2.1–2.6
R–O–C–**H**	3.1–3.9
RC**H**$_2$Cl or Br	3.1–4.2
R–C(=O)–O–C–**H**	3.7–4.1
RC=C**H** (R and **H** on C=C)	4.5–6.0
R–C(=O)–**H**	9.0–10.0
R–C(=O)–O–**H**	10.0–12.0

Table 3
^{13}C n.m.r. chemical shift data

Type of carbon	δ/ppm
–**C**–**C**–	5–40
R–**C**–Cl or Br	10–70
R–C(=O)–**C**–	20–50
R–**C**–N	25–60
–**C**–O– (alcohols, ethers or esters)	50–90
C=**C**	90–150
R–**C**≡N	110–125
benzene ring	110–160
R–**C**(=O)– (esters or acids)	160–185
R–**C**(=O)– (aldehydes or ketones)	190–220

The Periodic Table of the Elements

Key

relative atomic mass **symbol** name atomic (proton) number

1 (1)	**2** (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	**3** (13)	**4** (14)	**5** (15)	**6** (16)	**7** (17)	**0** (18)
							1.0 **H** hydrogen 1										4.0 **He** helium 2
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											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						

*** 58 – 71** Lanthanides	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
† 90 – 103 Actinides	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