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 Subsidiary Examination
June 2010

Chemistry CHM3T/P10/test

Unit 3T AS 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 .....

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Section A

These questions are about the task, the determination of the concentration of ethanoic acid in vinegar.

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 .....

(1 mark)

2 The equation for the reaction between ethanoic acid and sodium hydroxide is shown below.

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

The concentration of the sodium hydroxide solution used was 0.100 mol dm^{-3}.
Use the average titre from Question **1** to calculate the concentration, in mol dm^{-3}, of ethanoic acid in the diluted vinegar solution.
Show your working.

.....

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.....

.....

(2 marks)

3 You were provided with a **diluted** vinegar solution. This diluted solution was prepared by pipetting 25.0 cm^3 of the **original** vinegar solution into a 250 cm^3 volumetric (graduated) flask and making up to the mark with distilled water. Use your answer from Question **2** to determine the concentration, in mol dm^{-3}, of ethanoic acid in the **original** vinegar solution.

.....

(1 mark)

4 Use data from the Periodic Table to calculate the relative molecular mass of ethanoic acid (CH_3COOH). Give your answer to the appropriate precision.

.....

(1 mark)

5 Use your answers from Questions **3** and **4** to determine the concentration, in g dm^{-3}, of ethanoic acid in the **original** vinegar solution.

.....

.....

(1 mark)

6 The manufacturer supplying the vinegar claimed that the concentration of the ethanoic acid in the **original** vinegar solution was 55.0 g dm^{-3}. Calculate the difference between your value from Question **5** and the manufacturer's value. Express this difference as a percentage of the manufacturer's value.

(If you could not complete the calculation in Question **5**, you should assume that the concentration of ethanoic acid in the original vinegar solution is 40.5 g dm^{-3}. This is **not** the correct value.)

Difference .....

Percentage .....

.....

(2 marks)

7 The maximum total error in using the burette is ± 0.15 cm^3. This error takes into account multiple measurements. Use the average titre from Question **1** to calculate the percentage error in using the burette.

.....

.....

(1 mark)

8 You are provided with a sample of the original vinegar solution. Give **one** change you could make to reduce the percentage error in using the burette.

.....

.....

(1 mark)

9 Vinegar contains other substances which improve flavour. Suggest **one** reason why these substances could affect the titration with sodium hydroxide.

.....

.....

(1 mark)

10 Suggest why the manufacturer checks the concentration of the ethanoic acid in several batches of vinegar.

.....

.....

(1 mark)

12

Turn over for the next question

Section B

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

11 The manufacturer of vinegar buys concentrated ethanoic acid as a 15.0 mol dm^{-3} solution. In case of an accidental spillage of this ethanoic acid the manufacturer always has sodium carbonate readily available to neutralise the acid. The equation for this reaction is shown below.

$$2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COONa + H_2O + CO_2$$

11 (a) Calculate the amount, in moles, of ethanoic acid in 10.0 cm^3 of a 15.0 mol dm^{-3} solution.

.....

(1 mark)

11 (b) Use your answer from part **(a)** to calculate the amount, in moles, of sodium carbonate needed to react completely with this amount of ethanoic acid.

.....

(1 mark)

11 (c) Use data from the Periodic Table to calculate the relative formula mass of sodium carbonate. Give your answer to the appropriate precision.

.....

(1 mark)

11 (d) Use your answers from parts **(b)** and **(c)** to determine the minimum mass of sodium carbonate needed to react completely with 10.0 cm^3 of the 15.0 mol dm^{-3} solution of ethanoic acid.

.....

(1 mark)

12 State **one** hazard when using concentrated ethanoic acid and **one** safety precaution you would take to minimise this hazard.

Hazard .....

Precaution .....

.....

(1 mark)

13 Sodium hydrogencarbonate ($NaHCO_3$) can also be used to neutralise ethanoic acid spillages. The equation for this reaction is shown below.

$$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + H_2O + CO_2$$

13 (a) State the ideal gas equation.

.....

(1 mark)

13 (b) An excess of sodium hydrogencarbonate was added to a 10.0 cm^3 sample of a 15.0 mol dm^{-3} solution of ethanoic acid. Use the ideal gas equation and your answer from Question **11 (a)** to calculate the volume of carbon dioxide gas that would be formed at 20 ºC and 1.00 x 10^5 Pa.
Show your working.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

(If you could not complete the calculation in Question **11(a)**, you should assume the number of moles of ethanoic acid is 0.120 mole. This is **not** the correct answer.)

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.....

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(3 marks)

14 There are several methods by which ethanoic acid is synthesised on an industrial scale. One method is the oxidation of butane in the presence of metal ion catalysts. Balance the equation given below which summarises this reaction.

.....C_4H_{10} + ...O_2 ⟶ .....CH_3COOH + ...H_2O *(1 mark)*

15 A second method by which ethanoic acid is synthesised involves the oxidative fermentation of ethanol in the presence of bacteria. The equation representing this reaction is given below.

$$C_2H_5OH + O_2 \longrightarrow CH_3COOH + H_2O$$

In a small scale experiment using this second method it was found that 23.0 g of ethanol produced only 4.54 g of ethanoic acid. Calculate the percentage yield for this experiment.

.....

.....

.....

(2 marks)

Turn over ▶

16 The manufacturer supplying concentrated ethanoic acid for the production of vinegar also supplied other acids. The label had come off a batch of one of these other acids. A sample of this unknown acid was analysed and found to contain 54.5% of carbon and 9.10% of hydrogen by mass, the remainder being oxygen.

16 (a) Use these data to calculate the empirical formula of the unknown acid.
Show your working.

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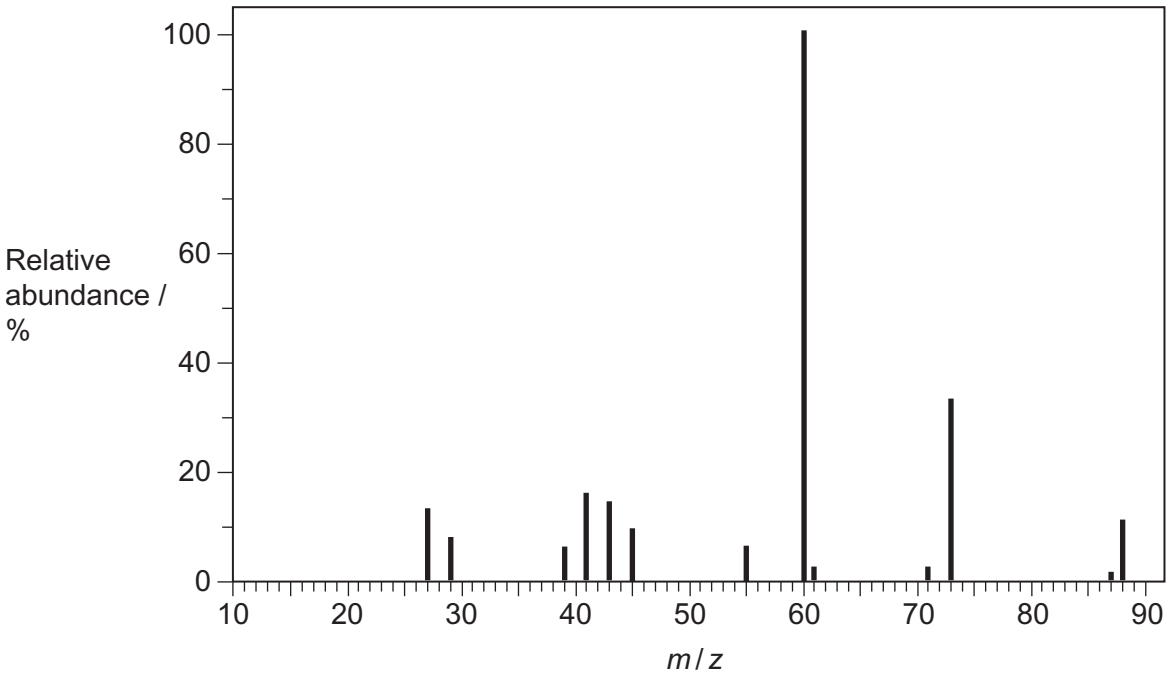
.....

(3 marks)

16 (b) A sample of the unknown acid was analysed in a mass spectrometer. The mass spectrum obtained is shown below.



Use the mass spectrum to determine the M_r of the unknown acid.

.....

(1 mark)

16 (c) Use your answers from parts **(a)** and **(b)** to determine the molecular formula of the unknown acid.
(If you could not answer part **(b)**, you should assume that the M_r of the acid is 132.0 but this is **not** the correct value.)
Show your working.

.....

.....

.....

(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

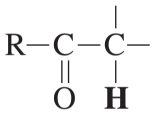
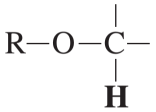
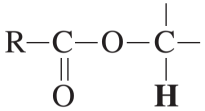
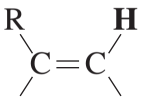
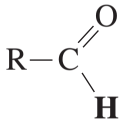
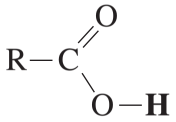
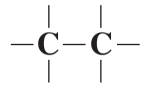
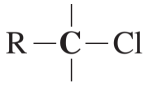
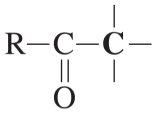
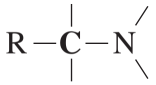
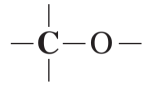
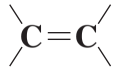
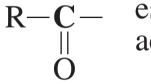
Type of proton	δ/ppm
ROH	0.5 – 5.0
RCH$_3$	0.7 – 1.2
RNH$_2$	1.0 – 4.5
R$_2$CH$_2$	1.2 – 1.4
R$_3$CH	1.4 – 1.6
	2.1 – 2.6
	3.1 – 3.9
RCH$_2$Cl or Br	3.1 – 4.2
	3.7 – 4.1
	4.5 – 6.0
	9.0 – 10.0
	10.0 – 12.0

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
R—C≡N	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