Centre Number						Candidate Number				
Surname						Other Names				

Notice to Candidate. The work you submit for assessment must be your own. If you copy from someone else or allow another candidate to copy from you, or if you cheat in any other way, you may be disqualified.

Candidate Declaration. I have read and understood the Notice to Candidate and can confirm that I have produced the attached work without assistance other than that which is acceptable under the scheme of assessment.

Candidate Signature		Date	

For Teacher's Use	
Section	Mark
PSA	
Task	
Section A	
Section B	
TOTAL (max 50)	

AQA

General Certificate of Education
Advanced Level Examination
June 2014

Chemistry CHM6T/P14/test/v2

Unit 6T A2 Investigative Skills Assignment

Written Test

For submission by 15 May 2014

For this paper you must have:	**Time allowed**
• 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.	• 1 hour
Instructions	**Information**
• 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.	• The marks for questions are shown in brackets. • The maximum mark for this paper is 30. • You are expected to use a calculator, where appropriate. • You will be marked on your ability to: – organise information clearly – use scientific terminology accurately.

Details of additional assistance (if any). Did the candidate receive any help or information in the production of this work? If you answer yes give the details below or on a separate page.

Yes ☐ No ☐

Teacher Declaration:
I confirm that the candidate's work was conducted under the conditions laid out by the specification. I have authenticated the candidate's work and am satisfied that to the best of my knowledge the work produced is solely that of the candidate.

Signature of teacher ..... Date .....

Section A

These questions are about the task, the determination of an equilibrium constant.

You should use your Task Sheet, including your own Candidate Results Sheet, to answer these questions.

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

1 Record the average titre from your Candidate Results Sheet.

[1 mark]

.....

2 The concentration of the sodium hydroxide solution used in the task was 0.200 mol dm^{-3}.

Use your answer to Question **1** to determine the total amount, in moles, of acid ($H^+(aq)$) in **the volumetric flask**. Show your working.

[2 marks]

.....

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.....

3 In Part 1 of the task, 0.00400 mol of $H^+(aq)$ was added in the form of dilute sulfuric acid.

3 (a) State the role of the sulfuric acid in the esterification reaction.

[1 mark]

.....

3 (b) Use your answer to Question **2** to calculate the amount, in moles, of ethanoic acid that must have been present in the equilibrium mixture in the boiling tube.

[1 mark]

.....

.....

3 (c) The initial mixture in the boiling tube contained 0.105 mol of ethanoic acid.

Use your answer to Question **3 (b)** to calculate the amount, in moles, of ethanoic acid that must have reacted to form the ester in the equilibrium mixture.

[1 mark]

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4 Suggest why the pink colour of the phenolphthalein fades after the end-point of the titration has been reached. Ignore any absorption of acidic gases from the atmosphere.

[2 marks]

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5 The equation for the equilibrium established in the task is

$$CH_3COOH + CH_3CH_2CH_2OH \rightleftharpoons CH_3COOCH_2CH_2CH_3 + H_2O$$

In Part 1 of the task, the initial mixture contained 0.105 mol of ethanoic acid, 0.080 mol of propan-1-ol and 0.111 mol of water (from the dilute sulfuric acid).

Use your answer to Question **3 (c)** to deduce the amounts, in moles, of propan-1-ol, propyl ethanoate and water that must have been in the equilibrium mixture.

(If you were unable to complete Question **3 (c)**, you may assume that the amount of ethanoic acid that had reacted was 0.037 mol. This is **not** the correct answer.)

[3 marks]

Amount of propan-1-ol .....

Amount of propyl ethanoate .....

Amount of water .....

6 Deduce an expression for the equilibrium constant (K_c) for the reaction shown in Question **5**.
Use your answers to Questions **3 (b)** and **5** to calculate a value for K_c
Give your answer to 3 significant figures.

[2 marks]

Expression for K_c .....

.....

Calculation .....

.....

.....

7 Explain briefly what you could do to confirm that 1 week was sufficient time for equilibrium to be established in the mixture from Part 1.

[2 marks]

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8 A student repeated the experiment but filled the volumetric flask significantly above the graduation mark. The student then completed the rest of the task correctly.

Explain why this error results in a higher calculated value of K_c

[2 marks]

.....

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17

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Section B

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

9 In an experiment to determine the acid dissociation constant (K_a) of a weak acid, 25.0 cm^3 of an approximately 0.1 mol dm^{-3} solution of this acid were titrated with a 0.10 mol dm^{-3} solution of sodium hydroxide.
The pH was measured at intervals and recorded. **Table 1** shows the results.

Table 1

Volume of NaOH / cm^3	0.0	1.0	2.0	3.0	4.0	5.0	10.0	15.0
pH	5.1	7.8	8.1	8.7	8.4	8.5	8.9	9.3

Volume of NaOH / cm^3	20.0	22.0	23.0	24.0	25.0	26.0	27.0	28.0
pH	9.7	10.0	10.2	11.0	11.3	11.4	11.5	11.6

9 (a) On the grid on page 7, plot the values from **Table 1** on a graph of pH (*y*-axis) against volume of NaOH
You should start your *y*-axis at pH 4.0
Draw a curve that represents the curve of best fit through these points. Ignore any anomalous points.

[4 marks]

9 (b) Deduce the volume of the sodium hydroxide solution that would have been added at the half-neutralisation point of this experiment. This is the point where half the amount of the weak acid has been neutralised.

[1 mark]

.....

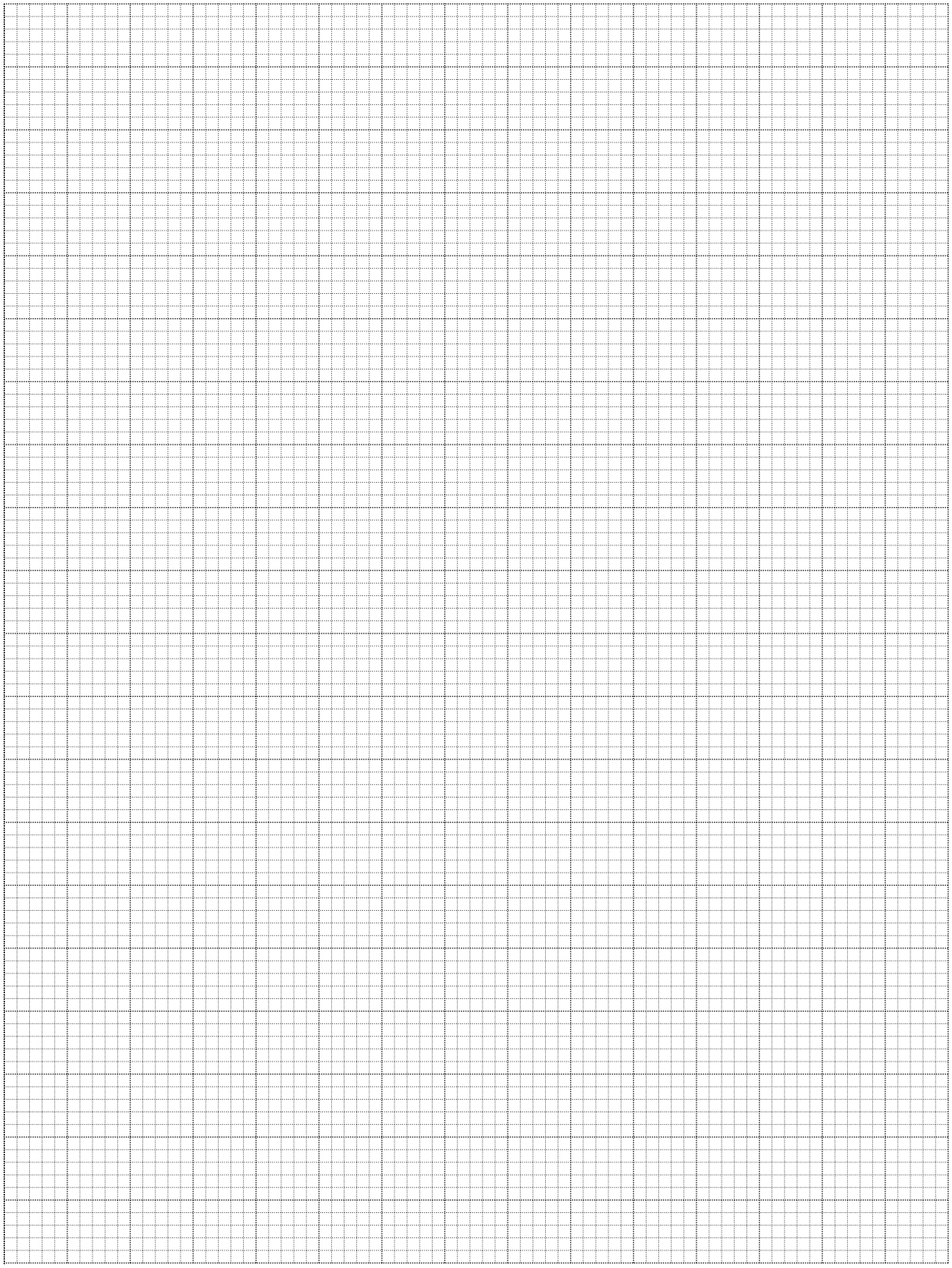
9 (c) When half of the weak acid has been neutralised, the pH of the mixture at this point is equal to the pK_a of the weak acid.

Use your answer to Question **9 (b)** and your graph to determine the pK_a of the weak acid and, hence, its K_a value.

[2 marks]

pK_a .....

K_a .....



Question 9 continues on the next page

9 (d) State the pH value for the anomalous point on your graph.
Suggest **one** reason for this anomaly. Assume that the reading on the pH meter is correct.

[1 mark]

pH .....

Reason for anomaly .....

.....

.....

9 (e) Suggest how the experimental procedure could be slightly modified in order to give a more reliable value for the end-point.

[1 mark]

.....

.....

.....

10 Ethanoic acid, propyl ethanoate and propan-1-ol are all colourless liquids. Esters do **not** give a positive result with any of the usual tests for functional groups.

State how you could use chemical tests to show the presence of ethanoic acid and propan-1-ol in a mixture of the acid, the alcohol and the ester.

[4 marks]

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13

END OF QUESTIONS

GCE Chemistry Data Sheet

Table A

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 B

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

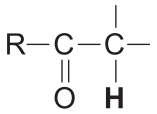
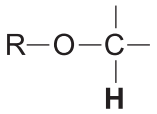
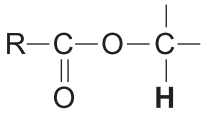
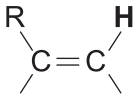
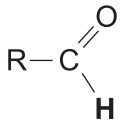
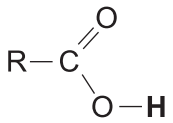
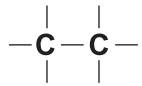
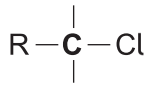
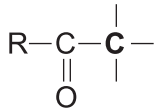
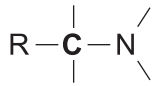
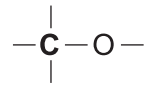
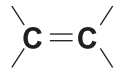
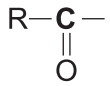
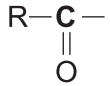
Type of proton	δ/ppm
ROH	0.5 – 5.0
RCH$_3$	0.7 – 1.2
RNH$_2$	1.0 – 4.5
R$_2$CH$_2$	1.2 – 1.4
R$_3$CH	1.4 – 1.6
	2.1 – 2.6
	3.1 – 3.9
RCH$_2$Cl or Br	3.1 – 4.2
	3.7 – 4.1
	4.5 – 6.0
	9.0 – 10.0
	10.0 – 12.0

Table C

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

Type of carbon	δ/ppm
	5 – 40
	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)	*(2)*											*(13)*	*(14)*	*(15)*	*(16)*	*(17)*	*(18)*
			Key				1.0 **H** hydrogen 1										4.0 **He** helium 2
6.9 **Li** lithium 3	9.0 **Be** beryllium 4		relative atomic mass **symbol** name atomic (proton) number									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