Name: Class: Date:

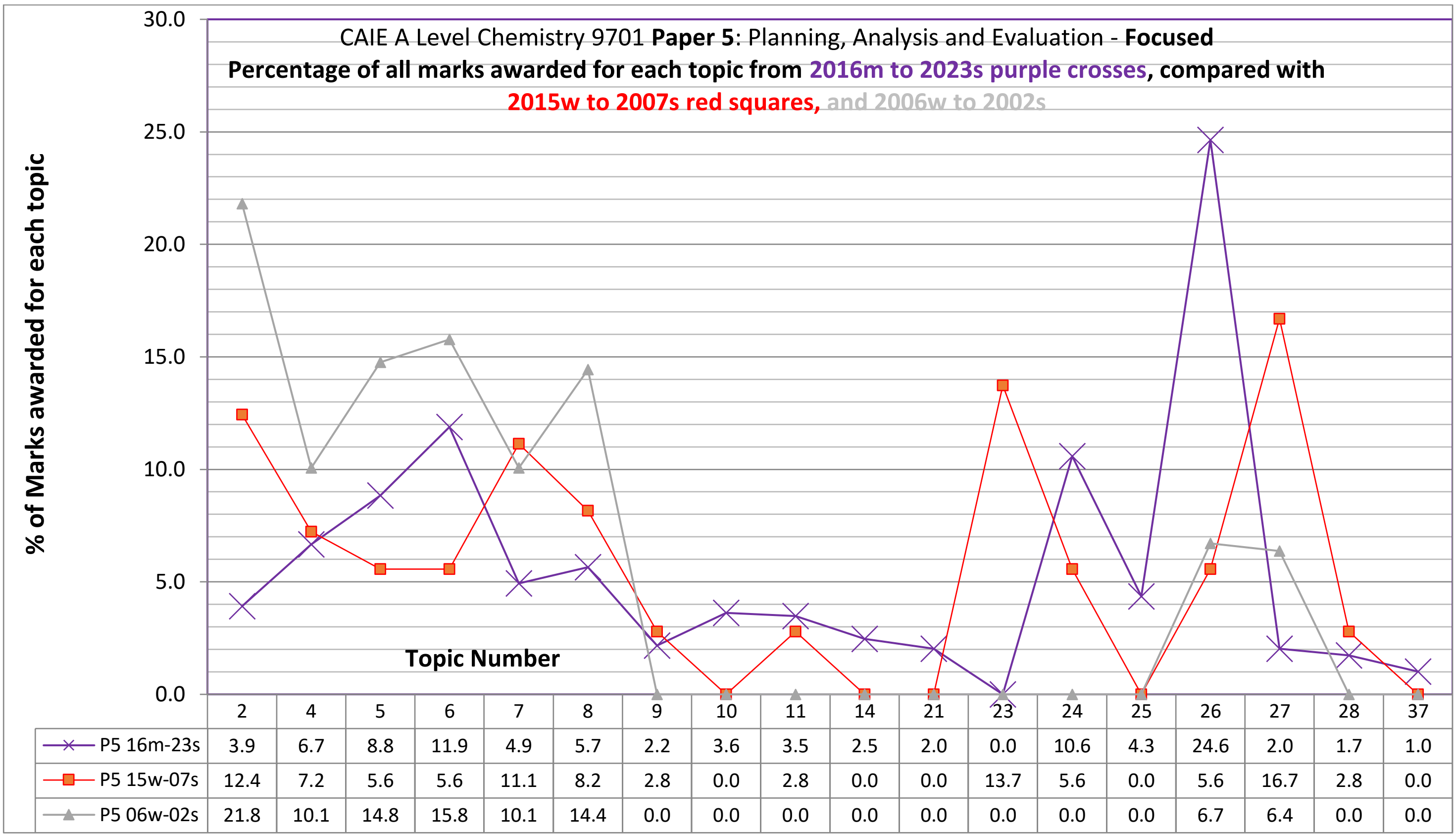
ALvl Chem 7 EQ P5 22w to 02s Paper 5 Equilibria 109marks

These questions are from an A2 Exam Paper on AS material. Most AS students will not benefit from working on these questions until their A2 year. AS students aiming for an A* *might* get some value looking at these questions, but only if they have made substantial progress in AS, so at least a "Winner" (50%) level or beyond for Papers 1, 2 and 3!

As you start and work through this worksheet you can tick off your progress to show yourself how much you have done, and what you need to do next. The first task is just to read the first question and should take you less than 3 minutes to complete.

Paper 5 Topic 7 Checklist Tick each task off as you go along

	RANK:	P5 Noob	P5 Novice	P5 Bronze	P5 Silver	P4 Gold	P5[1] Winner	P5 Hero	P5 Legend
	Marks	1 Q Started	1 Q done	10% of marks	25% of marks	40% of marks	50% of marks	75% of marks	100% of marks
Topic (marks)	109		16	11	27	44	55	82	109
Time @150s/mark (minutes)	273		39	27	68	109	136	204	273



	2	4	5	6	7	8	9	10	11	14	21	23	24	25	26	27	28	37
P5 16m-23s	3.9	6.7	8.8	11.9	4.9	5.7	2.2	3.6	3.5	2.5	2.0	0.0	10.6	4.3	24.6	2.0	1.7	1.0
P5 15w-07s	12.4	7.2	5.6	5.6	11.1	8.2	2.8	0.0	2.8	0.0	0.0	13.7	5.6	0.0	5.6	16.7	2.8	0.0
P5 06w-02s	21.8	10.1	14.8	15.8	10.1	14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	6.4	0.0	0.0

What the most thoughtful students will get out of their extensive studying will be a capacity to do meaningful brain-based work even under stressful conditions, which is a part of the self-mastery skillset that will continue to deliver value for the whole of their lives. Outstanding grades will also happen, but the most important outcome from skillful action in study is being better at any important tasks even if circumstances are do not feel ideal.

Learning how to manage oneself so we can more reliably get ambitious and successful outcomes out of our challenges in a productive and positive way is one aspect of life's most valuable pursuit summarised and inscribed on the Temple of Apollo at Delphi: "know thyself".

1. To complete these questions, as important as your answer, is checking your answer against the mark scheme.
2. For each question, or page, convert your mark score into a percentage. This will allow you to see (and feel) your progress as you get more experience and understanding with each topic.

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[1] **DO NOT** work on these higher levels of completion in your A2 year unless you have also achieved at least a "**Gold**" (40%) in the same topic in **Paper 4**, which is **MOST** of your **A2 grade**.

3. If you find you get a higher percentage answering short answer questions than multiple choice questions that often means you are using the marking scheme correctly; your correct answer might not be fully complete. The marks easiest to miss rely on providing more details fully described.

Q# 42/ ALvl Chemistry/2020/s/TZ 1/ Paper 5/Q# 2/www.SmashingScience.org :o)

2 Nitrogen dioxide can be prepared by strongly heating anhydrous lead nitrate, $Pb(NO_3)_2(s)$. The thermal decomposition occurs according to the equation shown.

$$2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$$

The nitrogen dioxide, NO_2, can be separated from the oxygen by cooling the gas mixture produced until the NO_2 condenses and the oxygen does not.

	melting point / K	boiling point / K
nitrogen dioxide	262	294
oxygen	54	90

(a) Draw a labelled diagram of the laboratory apparatus (assembled) that could be used to prepare **liquid** nitrogen dioxide from the thermal decomposition of anhydrous lead nitrate.

[2]

(b) At room temperature, nitrogen dioxide exists in equilibrium with dinitrogen tetroxide according to the equation shown.

$$\underset{\text{brown}}{2NO_2(g)} \rightleftharpoons \underset{\text{colourless}}{N_2O_4(g)}$$

For this equilibrium, $K_p = p_{N_2O_4} / p^2_{NO_2}$.

$p_{N_2O_4}$ and p_{NO_2} are measured in kPa.

State the units of K_p.

.... [1]

A student plans to investigate the variation of K_p with temperature.

(c) **(i)** A sample of the mixture of nitrogen oxides is introduced into a gas syringe at 295 K and the gas syringe is sealed so that it is both airtight and watertight. The volume occupied by the mixture is measured at different temperatures. The K_p value is calculated at each temperature.

Name the apparatus you would use to heat the gas syringe at different temperatures between 295 K and 370 K so that a volume reading of the gas syringe could be easily taken.

.... [1]

(ii) The results obtained are shown in the table.

Complete the table by calculating values for $\frac{1}{T}$ and log K_p.

Record the value of $\frac{1}{T}$ to **three significant figures**.

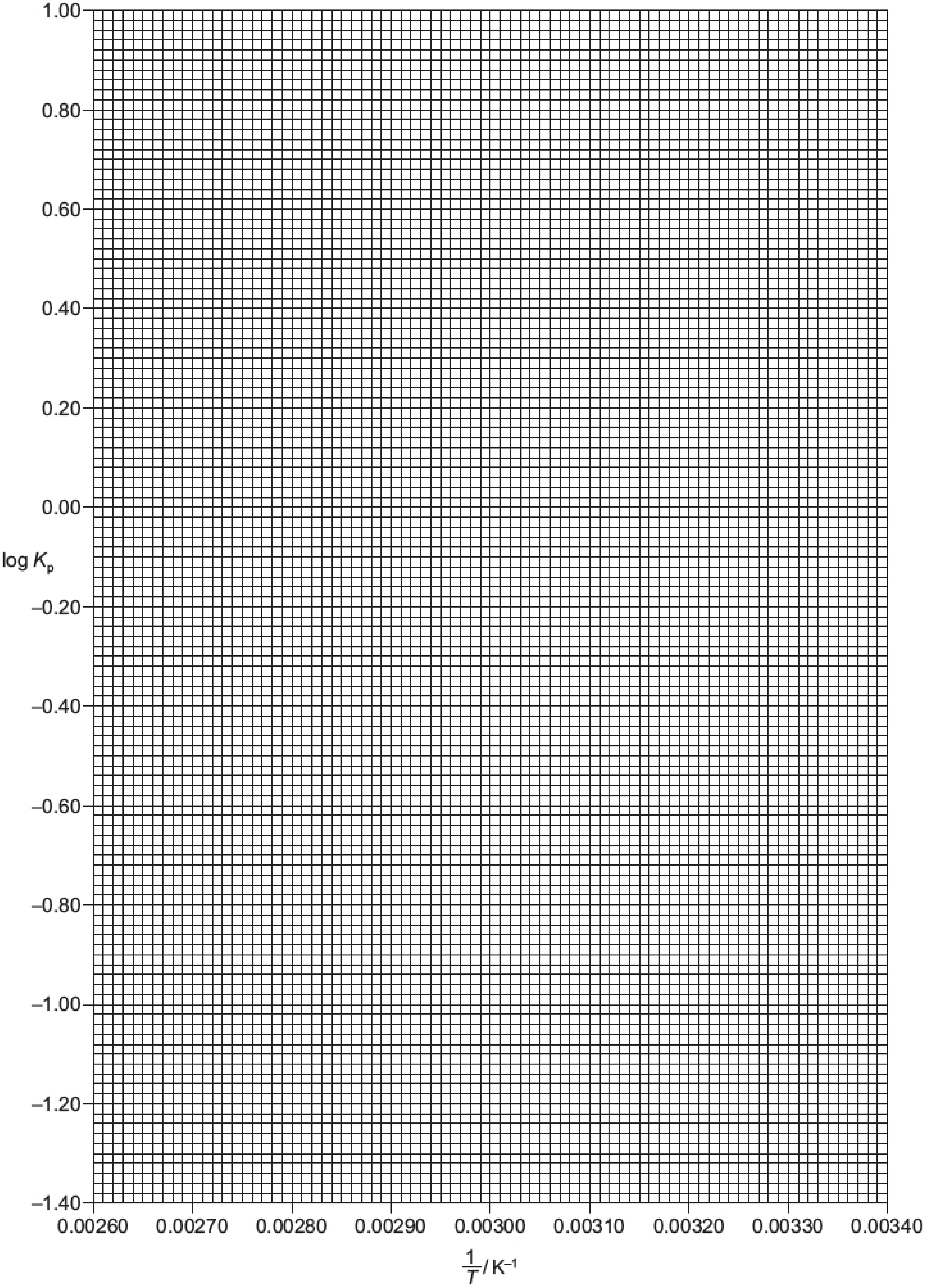
Record the value of log K_p to **two decimal places**.

T / K	$\frac{1}{T}$ / K^{-1}	K_p	log K_p
377		0.076	
361		0.122	
344		0.257	
330		0.741	
315		1.506	
312		3.490	
295		9.025	

[2]

(iii) Plot a graph on the grid of log K_p against $\frac{1}{T}$.

Draw a line of best fit through the plotted points. [2]


1.00
0.80
0.60
0.40
0.20
0.00
log K_p
–0.20
–0.40
–0.60
–0.80
–1.00
–1.20
–1.40
0.00260
0.00270
0.00280
0.00290
0.00300
0.00310
0.00320
0.00330
0.00340
$\frac{1}{T}$ / K^{-1}

(d) **(i)** State and explain what your graph shows about the accuracy of the experimental results.

....

....

.... [1]

(ii) Suggest a reason for your answer in **(d)(i)**.

....

.... [1]

(iii) Suggest what the student could do to improve the accuracy of the experiment.

....

.... [1]

(e) **(i)** Use the graph to determine the gradient of the line of best fit.

State the coordinates of both points you used in your calculation. These must be on your line of best fit.

Give your answer to **three significant figures**.

coordinates 1 .... coordinates 2 ....

gradient = ... K

[2]

(ii) The relationship between log K_p and $\frac{1}{T}$ is given by the equation shown.

$$\log K_p = (-\Delta H / 2.303 RT) + \text{constant}$$

$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$

Use the gradient determined to calculate a value for ΔH.

If you were unable to determine a value for the gradient, use the value 2800 K. This is **not** the correct value.

ΔH = ... kJ mol^{-1}

[2]

(f) (i) With reference to the results obtained in this experiment, state and explain how K_p varies with temperature.

....

.... [2]

(ii) With reference to **(b)** and the data for K_p in the table in **(c)(ii)** suggest how the colour of the equilibrium mixture at 370 K will differ, if at all, from the colour at room temperature. Explain your answer.

difference in colour of mixture ....

explanation ....

....

....

[2]

[Total: 19]

Q# 43/ ALvl Chemistry/2015/w/TZ 1/ Paper 5/Q# 2/www.SmashingScience.org :o)

2 In an experiment, various masses of solid barium hydroxide are added to 60.0 cm^3 of a solution of hydrochloric acid contained in a polystyrene cup.

In each experiment a fresh sample of the acid is taken and its initial temperature is measured. After the barium hydroxide has been added, the acid is stirred and the maximum temperature reached is noted.

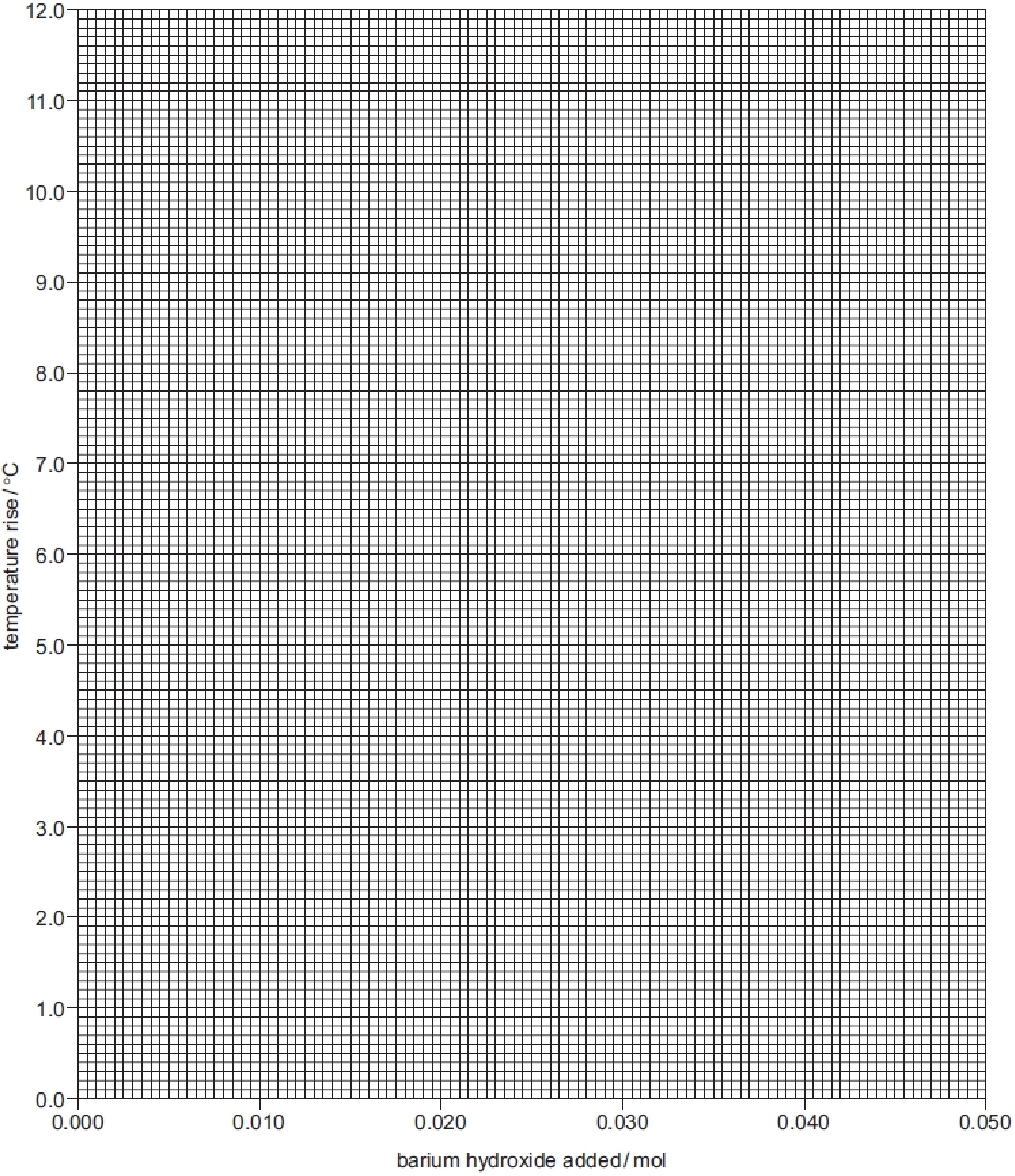
The results of each experiment are recorded in the table below.

(a) Complete the table below to give the temperature rise obtained from each experiment to **one decimal place** and the amount of barium hydroxide used in mol to **three significant figures** in each case.
The mass of 1 mol of barium hydroxide is 171 g.

initial temperature of HC*l*/°C	mass of barium hydroxide added /g	maximum temperature reached/°C	temperature rise/°C	barium hydroxide added/mol
21.0	0.500	22.2		
20.6	1.00	23.0		
21.2	1.50	24.9		
21.8	2.00	26.5		
20.5	3.00	27.8		
21.4	4.00	31.1		
21.2	5.00	31.6		
21.0	6.00	31.4		
20.8	8.00	31.2		

[2]

(b) **(i)** Using the grid on page 7, plot a graph to show how the temperature rise varies with the moles of barium hydroxide added. [1]



(ii) Draw **two** lines of best fit on your graph and state the value on the *x*-axis at the point of intersection of the two lines.

value on the *x*-axis at the point of intersection is .... [2]

(c) Use the value on the *x*-axis at the point of intersection to calculate the concentration of the hydrochloric acid in mol dm^{-3}.

[2]

(d) Explain the variation in temperature that takes place when barium hydroxide is added to the hydrochloric acid.

....

....

....

....

....

.... [2]

(e) **(i)** When the experiment is done in the way described, the results are not very accurate.

Apart from limitations due to the accuracy of the measuring equipment, suggest why:

- all the temperature rises measured are less than theoretically should be expected,

....

....

- the temperature rises are more inaccurate as they approach their maximum value.

....

....

[2]

(ii) What improvement would you make to achieve greater accuracy?

....

....

....

.... [1]

(f) In another experiment, 60.0 cm^3 of ethanoic acid is used instead of the 60.0 cm^3 of hydrochloric acid.

If the ethanoic acid has the same concentration as the hydrochloric acid, draw on your graph another pair of lines to show the results you would expect to obtain.

Explain your answer.

....

....

....

....

....

.... [3]

[Total: 15]

2 At high temperatures a mixture of iodine and hydrogen gases reacts to form an equilibrium with gaseous hydrogen iodide.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(a) **(i)** Write an expression for the equilibrium constant, K_c, based on concentration, for this reaction.

[1]

(ii) If the starting concentration of both iodine and hydrogen was **a** mol dm^{-3} and it was found that 2**y** mol dm^{-3} of hydrogen iodide had formed once equilibrium had been established, write K_c in terms of **a** and **y**.

[1]

(b) The expression for the equilibrium constant from **(a)(ii)** can be re-written as shown below.

$$\mathbf{y} = \frac{\mathbf{a}\sqrt{K_c}}{2 + \sqrt{K_c}}$$

In an experiment, air was removed from a 1 dm^3 flask and amounts of hydrogen and iodine gases were mixed together such that their initial concentrations were both **a** mol dm^{-3}. This mixture was allowed to come to equilibrium at 760 K in the flask. The equilibrium concentration of iodine, (**a** – **y**) mol dm^{-3}, was then measured.

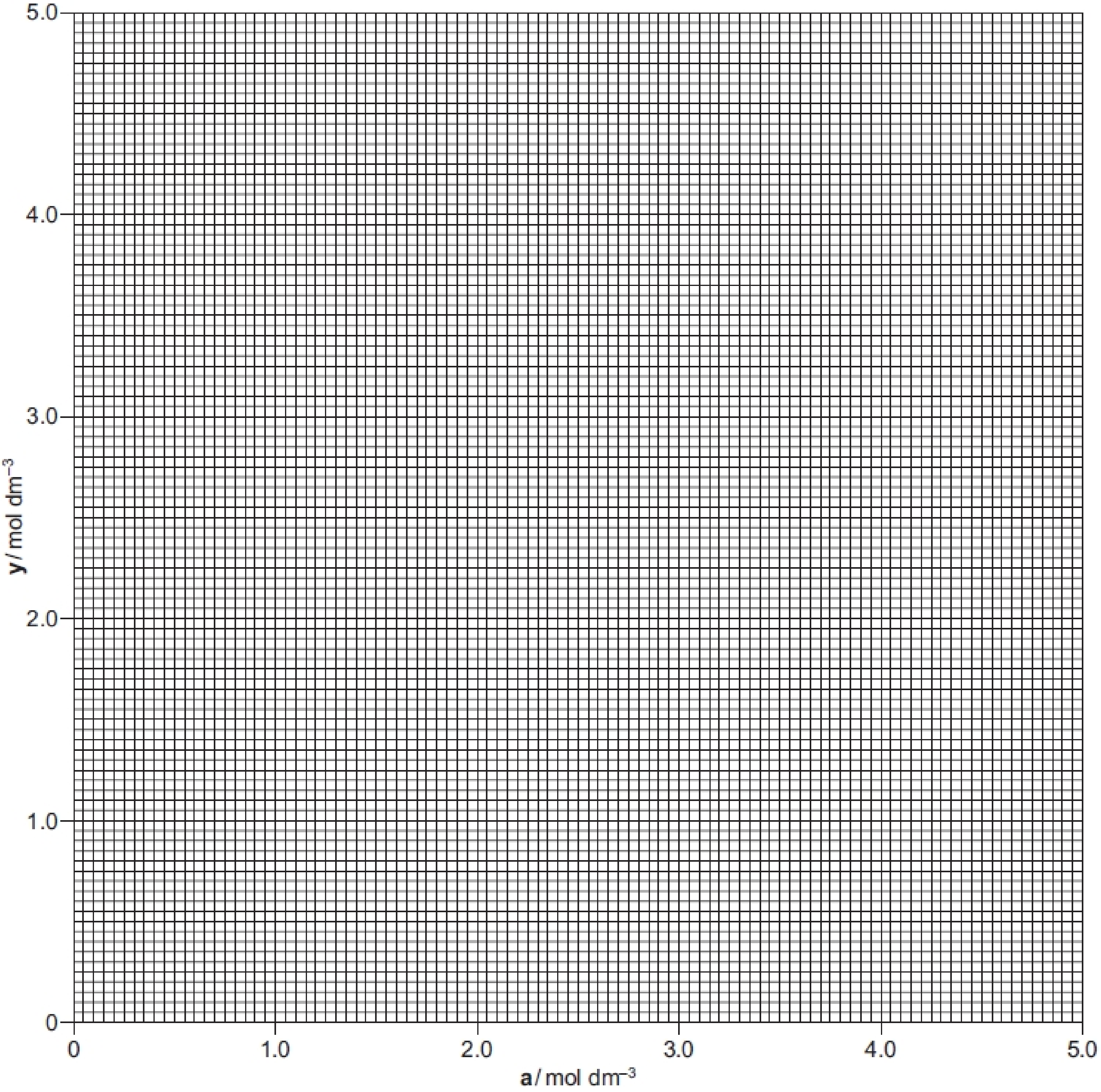
The experiment was repeated for various initial concentrations, **a** mol dm^{-3}, and the results were recorded in the table below.

(i) Complete the table to give the values of **y** mol dm^{-3} to **three decimal places**.

a mol dm^{-3}	**(a – y) mol dm^{-3}**	**y mol dm^{-3}**
0.200	0.022	0.178
0.500	0.050	
0.800	0.252	
1.000	0.200	
1.500	0.365	
2.100	0.570	
2.800	0.652	
3.400	0.700	
3.800	0.867	
4.200	0.868	
4.900	1.150	

[2]

(ii) Plot a graph to show how **y** mol dm^{-3} varies with initial concentrations of hydrogen and iodine, **a** mol dm^{-3}.



[1]

(iii) Use your points to draw a line of best fit. [1]

(c) **(i)** Determine the slope of your graph. State the co-ordinates of both points you used for your calculation. Record the value of the slope to **three significant figures**.

co-ordinates of both points used ....

slope = ...

[2]

(ii) Use the value of your slope and the equation in **(b)** to calculate the value of K_c. Your working **must** be shown.

[2]

(d) Explain why, for safety reasons, it is necessary to remove air from the 1 dm^3 flask.

....

.... [1]

(e) One of the experiments in **(b)** was repeated in a 500 cm^3 flask instead of the 1 dm^3 flask.

What effect, if any, would this have on the rate of reaction and the value of K_c measured?

....

....

....

....

.... [2]

(f) The reaction of hydrogen and iodine to form hydrogen iodide is exothermic.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = -9.6\,\text{kJ mol}^{-1}$$

(i) On your graph, draw and label the line you would expect if the experiment was performed at 1000 K instead of 760 K. [1]

(ii) What effect, if any, would the higher temperature have on the value of K_c?

....

.... [1]

[Total: 15]

Q# 45/ ALvl Chemistry/2015/s/TZ 1/ Paper 5/Q# 1/www.SmashingScience.org :o)

1 A saturated aqueous solution of magnesium methanoate, $Mg(HCOO)_2$, has a solubility of approximately 150 g dm^{-3} at room temperature. Its exact solubility can be determined by titrating magnesium methanoate against aqueous potassium manganate(VII).

During the titration, the methanoate ion, $HCOO^-$, is oxidised to carbon dioxide while the manganate(VII) ion, MnO_4^-, is reduced to Mn^{2+}.

You are supplied with:
a saturated aqueous solution of $Mg(HCOO)_2$
aqueous potassium manganate(VII), $KMnO_4$, of concentration 0.0200 mol dm^{-3}

(a) **(i)** Write the half equations for the oxidation of $HCOO^-$(aq) to CO_2(g) and the reduction of MnO_4^-(aq) to Mn^{2+}(aq) in acid solution.

....

.... [2]

(ii) Using the approximate solubility above, calculate the concentration, in mol dm^{-3}, of the saturated aqueous magnesium methanoate and the concentration of the methanoate ions present in this solution.
[A_r: H, 1.0; C, 12.0; O, 16.0; Mg, 24.3]

[2]

(iii) In order to obtain a reliable titre value, the saturated solution of magnesium methanoate needs to be diluted.

Describe how you would accurately measure a 5.0 cm^3 sample of saturated magnesium methanoate solution and use it to prepare a solution fifty times more dilute than the saturated solution.

....

....

....

.... [2]

(iv) Before the titration is carried out, dilute sulfuric acid must be added to the magnesium methanoate.

Explain why this is necessary and also whether the volume of sulfuric acid chosen will affect the result of the titration.

....

....

....

.... [2]

(v) The potassium manganate(VII) is added from a burette into the magnesium methanoate in a conical flask.

Describe what you would see when you had reached the end-point of the titration.

....

.... [1]

(vi) 1 mol of acidified MnO_4^- ions reacts with 2.5 mol of $HCOO^-$ ions.

25.0 cm^3 of the diluted solution prepared in **(iii)** required 25.50 cm^3 of 0.0200 mol dm^{-3} potassium manganate(VII) solution to reach the end-point.

Use this information to calculate the concentration, in mol dm^{-3}, of $HCOO^-$ ions in the diluted solution.

.... mol dm^{-3} [1]

(vii) Use your answer to **(vi)** to calculate the concentration, in mol dm^{-3}, of the saturated solution of magnesium methanoate, $Mg(HCOO)_2$. Give your answer to **three significant figures**.

.... mol dm^{-3} [1]

(b) The solubility of magnesium methanoate can be determined at higher temperatures using the same titration.

In an experiment to determine how the concentration of saturated magnesium methanoate varies with temperature, name the independent variable and the dependent variable.

independent variable ....

dependent variable ....

[1]

(c) The solubility of magnesium methanoate increases with temperature.

What does this tell you about Δ*H* for the process below?

$$Mg(HCOO)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2HCOO^-(aq)$$

Explain your answer.

....

....

....

.... [2]

(d) A student used the same titration method, this time to measure the concentration of a saturated solution of *barium* methanoate.

Explain why the acidification of the solution with dilute sulfuric acid might make the titration difficult to do.

....

.... [1]

[Total: 15]

Q# 46/ ALvl Chemistry/2014/w/TZ 1/ Paper 5/Q# 2/www.SmashingScience.org :o)

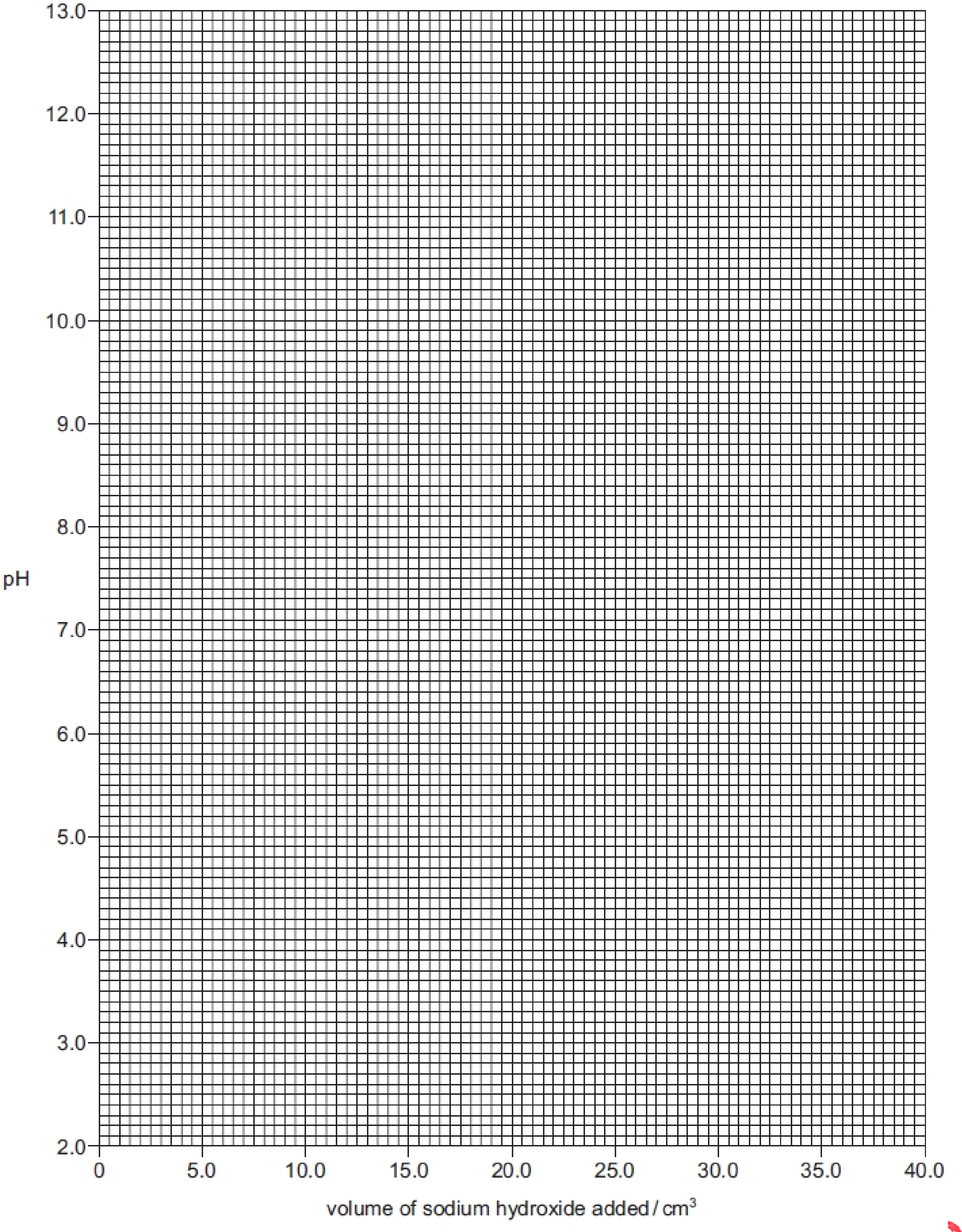
2 The acid dissociation constant, K_a, of a weak monoprotic acid, **HA**, is to be determined from the measurement of the pH change that occurs when it is titrated with an aqueous solution of sodium hydroxide.

2.70 g of **HA** was dissolved in distilled water to make exactly 250.0 cm^3 of solution.
25.00 cm^3 of the solution was pipetted into a beaker.
The pH of the acid in the beaker was measured and recorded in the table below.

A burette was then filled with aqueous sodium hydroxide and the 25.00 cm^3 of **HA** was titrated by adding volumes of the aqueous sodium hydroxide to the beaker as indicated in the table below. After each addition the pH was measured and the value recorded.

volume of sodium hydroxide added / cm^3	pH measured
0.00	2.41
2.00	2.75
4.00	3.09
8.00	3.46
12.00	3.52
16.00	3.96
20.00	4.20
24.00	4.50
28.00	5.05
30.00	7.00
32.00	11.55
36.00	12.00

(a) Plot a graph to show how the pH of the mixture changes with the volume of added aqueous sodium hydroxide as shown in the table.
Draw a smooth curve, using the plotted points on your graph, to produce a titration curve for the addition of aqueous sodium hydroxide to the acid **HA**.



[2]

(b) Circle any points on the graph that are anomalous and suggest a reason why this might occur.

....

....

....

.... [2]

(c) What would be a suitable range of pH values in which an indicator would change colour to identify the end point of this neutralisation?

....

.... [1]

(d) 30.00 cm^3 of aqueous sodium hydroxide is required to neutralise 25.00 cm^3 of **HA** and the equation for the neutralisation is shown.

$$NaOH + HA \rightarrow NaA + H_2O$$

(i) Excluding water, state the three ions or molecules that will be present in the highest concentration when 15.00 cm^3 of aqueous sodium hydroxide has been added to 25.00 cm^3 of **HA**.

....

.... [1]

(ii) State and explain how the concentrations of these ions or molecules compare.

....

....

....

.... [2]

(e) Use your graph to determine the pH obtained when 15.00 cm^3 of aqueous sodium hydroxide is added to 25.00 cm^3 of **HA**. Use this pH to determine the value of K_a for **HA**.

[3]

(f) **(i)** Use your answer to **(e)** and the initial pH of **HA** from the table to calculate the concentration of **HA** in mol dm^{-3}.

[2]

(ii) Calculate the initial concentration of **HA**, in g dm^{-3}, and use this together with your answer to **(f)(i)** to calculate the relative molecular mass, M_r, of **HA**.
(Remember that 2.70 g of **HA** was dissolved in distilled water to make exactly 250.0 cm^3 of solution.)

[1]

(g) Even if the experiment is done very carefully with very accurate apparatus, the answer obtained for the molecular mass of **HA** is likely to be subject to error. Suggest why.

....

....

....

.... [1]

[Total: 15]

Q# 47/ ALvl Chemistry/2006/w/TZ 1/ Paper 5/Q# 1/www.SmashingScience.org :o)

EXPERIMENT Required, no longer needed from 2007 onwards.

1 **FB 1** is a solution of sulphuric acid.
FB 2 is 2.00 mol dm^{-3} sodium hydroxide, NaOH.

Determining the concentration of sulphuric acid by thermometric titration.

Record the temperature of each solution, taking care to wash and dry the thermometer before measuring the temperature of the second solution. Read the temperature to the nearest 0.5 °C, and record the temperature of each solution in Table 1.1. Calculate the average temperature of the two solutions.

Table 1.1

	/ °C
temperature of solution **FB 1**	
temperature of solution **FB 2**	
average temperature	

[2]

Support the plastic cup in a 250 cm^3 beaker. Use one of the measuring cylinders to transfer 40 cm^3 of **FB 2**, sodium hydroxide solution, into the plastic cup.
Replace the stopper or cover over **FB 2** to prevent any reaction of carbon dioxide in the air with the sodium hydroxide.

Using the second measuring cylinder transfer 10 cm^3 of **FB 1**, sulphuric acid, into the sodium hydroxide in the plastic cup. Stir the mixture with the thermometer and note the highest temperature obtained.
This temperature should be recorded in Table 1.2 for experiment 1.

Empty, rinse and dry the plastic cup. Repeat the experiment with the other mixtures shown in Table 1.2 and record the highest temperature reached in each mixture.

Table 1.2

experiment	1	2	3	4	5	6
volume of **FB 2** / cm^3	40	35	30	25	20	15
✱ volume of **FB 1** / cm^3 ✱	10	15	20	25	30	35
maximum temperature / °C						

For each experiment use the average initial temperature from Table 1.1 to calculate and record the temperature rise after mixing the solutions.

experiment	1	2	3	4	5	6
✱ moles of sodium hydroxide ✱	0.08	0.07	0.06	0.05	0.04	0.03
temperature rise / °C						

[4]

(a) Plot the temperature rise against moles of sodium hydroxide on the grid below. [2]

(b) Draw **two appropriate straight lines** through your plotted points to show an end-point for the neutralisation. [1]

(c) Deduce from your graph, the number of moles of sodium hydroxide that reacted at the end-point.

....mol
[1]

(d) Use your answer to **(c)** and data from the lines in Table 1.2 marked with asterisks (✱) to calculate the volume of sulphuric acid, **FB 1**, reacting at the end-point.

[1]

(e) Calculate how many moles of sulphuric acid reacted with the sodium hydroxide at the end-point.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

[1]

(f) Calculate, in mol dm^{-3}, the concentration of the sulphuric acid in **FB 1**.

[1]

Determining the enthalpy change for the reaction $H^+(aq) + NaOH(s) \rightarrow H_2O(l) + Na^+(aq)$

Empty, rinse and dry the plastic cup used in the first part of the question. Using a measuring cylinder transfer 50 cm^3 of **FB 1** into the cup. When the temperature is steady, record its value in Table 1.3.

Weigh the tube labelled **FB 3** which contains solid sodium hydroxide. Record the mass in Table 1.3. Tip the contents of the tube into the plastic cup, stir, and record the highest temperature achieved in Table 1.3.

Weigh the empty tube and record its mass in Table 1.3.

Table 1.3

initial temperature of **FB 1** / °C	
maximum temperature after mixing **FB 1** and **FB 3** / °C	
mass of tube + **FB 3** / g	
mass of empty tube / g	

Complete the table by calculating the temperature rise and mass of **FB 3** added.

temperature rise / °C	
mass of **FB 3** added / g	

[4]

(g) Calculate the heat energy released during the reaction of **FB 1** and **FB 3** in the cup.
[Assume that 4.3 J are required to raise the temperature of 1 cm^3 of solution by 1 °C.]

energy released ....
[1]

(h) Use data from Table 1.3 and your answer to **(f)** to calculate which of sodium hydroxide or sulphuric acid is in excess.
If you are unable to obtain a value in **(f)** use 1.50 mol dm^{-3} as the concentration of the sulphuric acid.

$$2NaOH(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

[A_r: Na, 23.0; O, 16.0; H, 1.0]

.... is in excess.
[1]

(i) Calculate the enthalpy change, Δ*H*, for the following reaction.

$$H^+(aq) + NaOH(s) \rightarrow H_2O(l) + Na^+(aq)$$

Δ*H* = ... kJ mol^{-1}
[1]

[Total: 20]

Q# 48/ ALvl Chemistry/2005/w/TZ 1/ Paper 5/Q# 2/www.SmashingScience.org :o)

EXPERIMENT Required, no longer needed from 2007 onwards.

2 ASSESSMENT OF PLANNING SKILLS

You are provided with solutions **FB 3**, **FB 4** and **FB 5**.

The solutions are:

1.0 mol dm^{-3} sodium hydroxide
1.0 mol dm^{-3} sulphuric acid
0.5 mol dm^{-3} sulphuric acid

You are to plan experiments that will enable you to identify the solution that matches each of **FB 3**, **FB 4** and **FB 5**.

You have available the following apparatus:

–10 °C to 110 °C thermometer,
100 cm^3 beaker,
the measuring cylinder from question 1.

The measuring cylinder should be rinsed thoroughly before each use.

(a) You are to identify, by the **minimum number** of practical steps, which of the solutions contains sodium hydroxide.

Your experiment(s) must use only the solutions and apparatus above.

Outline your method – with an explanation of the expected results.

....

....

....

....

....

.... [2]

Carry out your plan.

Results

[2]

DO NOT FORGET TO SHAKE YOUR FLASKS FOR QUESTION 1

(b) Plan and carry out further experiments to find which of the remaining solutions is 1 mol dm^{-3} sulphuric acid and which is 0.5 mol dm^{-3} sulphuric acid.

Outline your method – with an explanation of the expected results.

....

....

....

....

....

....

.... [2]

Carry out your plan and present your results in a suitable table.

Results

[3]

Identity of the solutions

FB 3 contains ....

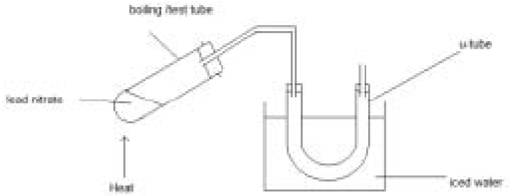
FB 4 contains ....

FB 5 contains .... [1]

[Total: 10]

NOW GO BACK AND COMPLETE QUESTION 1 IF YOU HAVE NOT ALREADY DONE SO

Q# 42/ ALvl Chemistry/2020/s/TZ 1/ Paper 5/Q# 2/www.SmashingScience.org :o)

<table>
<tr><td>2(a)</td><td>

M1 Heating a tube containing lead nitrate.
Labels: Lead nitrate AND Heat
A Bunsen for heat

M2 Use of iced water for cooling an unsealed collection vessel
Labels: Iced water
A Cold water</td><td>2</td></tr>
<tr><td>2(b)</td><td>kPa^{-1}</td><td>1</td></tr>
<tr><td>2(c)(i)</td><td>Thermostatically controlled water bath</td><td>1</td></tr>
<tr><td>2(c)(ii)</td><td>
<table>
<tr><th>T / K</th><th>1 / T / K^{-1}</th><th>Kp</th><th>Log$_{10}$Kp</th></tr>
<tr><td>377</td><td>0.00265</td><td>0.076</td><td>–1.12</td></tr>
<tr><td>361</td><td>0.00277</td><td>0.122</td><td>–0.91</td></tr>
<tr><td>344</td><td>0.00291</td><td>0.257</td><td>–0.59</td></tr>
<tr><td>330</td><td>0.00303</td><td>0.741</td><td>–0.13</td></tr>
<tr><td>315</td><td>0.00317</td><td>1.506</td><td>0.18</td></tr>
<tr><td>312</td><td>0.00320</td><td>3.490</td><td>0.54</td></tr>
<tr><td>295</td><td>0.00339</td><td>9.025</td><td>0.96</td></tr>
</table>
M1 Column 2 to 3 SF

M2 Column 4 to 2 DP</td><td>2</td></tr>
<tr><td rowspan="2">2(c)(iii)</td><td>M1 7 points plotted correctly</td><td>1</td></tr>
<tr><td>M2 Line of best fit drawn</td><td>1</td></tr>
<tr><td>2(d)(i)</td><td>Not accurate as there is a lot of scatter about the line of best fit</td><td>1</td></tr>
<tr><td>2(d)(ii)</td><td>Temperature of each experiment is difficult to record accurately</td><td>1</td></tr>
<tr><td>2(d)(iii)</td><td>Repeat and take an average</td><td>1</td></tr>
<tr><td rowspan="2">2(e)(i)</td><td>M1 Co-ordinates read and recorded correctly</td><td>1</td></tr>
<tr><td>M2 Gradient calculated to 3 SF</td><td>1</td></tr>
<tr><td rowspan="2">2(e)(ii)</td><td>M1 Rearrangement to show $-\Delta H/2.303R$ = Gradient</td><td>1</td></tr>
<tr><td>M2 Gradient x 2.303 x 8.31 correctly calculated</td><td>1</td></tr>
<tr><td rowspan="2">2(f)(i)</td><td>M1 <i>Kp</i> is inversely proportional to temperature</td><td>1</td></tr>
<tr><td>M2 Because ΔH has a negative value.</td><td>1</td></tr>
<tr><td rowspan="2">2(f)(ii)</td><td>M1 Darker brown</td><td>1</td></tr>
<tr><td>M2 Equilibrium shifts to left hand side (at higher temperatures).</td><td>1</td></tr>
</table>

<table>
<tr><td>2 (a)</td><td>
<table>
<tr><th>Temperature rise / °C</th><th>barium hydroxide added / mol</th></tr>
<tr><td>1.2</td><td>0.00292</td></tr>
<tr><td>2.4</td><td>0.00585</td></tr>
<tr><td>3.7</td><td>0.00877</td></tr>
<tr><td>4.7</td><td>0.0117</td></tr>
<tr><td>7.3</td><td>0.0175</td></tr>
<tr><td>9.7</td><td>0.0234</td></tr>
<tr><td>10.4</td><td>0.0292</td></tr>
<tr><td>10.4</td><td>0.0351</td></tr>
<tr><td>10.4</td><td>0.0468</td></tr>
</table>
Values in temperature column correct and to 1 decimal place
Values in barium hydroxide column are correct and to 3 sig figs</td><td>[1]
[1]</td></tr>
<tr><td>(b) (i)</td><td>All points plotted correctly</td><td>[1]</td></tr>
<tr><td>(ii)</td><td>Two best-fit straight lines drawn and then levelling to a horizontal line
The value on the x-axis is read correctly</td><td>[1]
[1]</td></tr>
<tr><td>(c)</td><td>The concentration of the acid is calculated as:
(2 × mol of $Ba(OH)_2$) × 1000 / 60</td><td>[2]</td></tr>
<tr><td>(d)</td><td>Exothermic reaction
After hydrochloric acid is neutralised / fully reacted OR barium hydroxide is in excess the temperature (rise) is constant</td><td>[1]
[1]</td></tr>
<tr><td>(e) (i)</td><td>Loss of heat (to the surroundings)
Greater temperature gradient OR the reaction is slower OR (rate of) heat loss is greater</td><td>[1]
[1]</td></tr>
<tr><td>(ii)</td><td>Give polystyrene cup a lid or cover / use a finer powder</td><td>[1]</td></tr>
</table>

(f)	Line rises less steeply and intersects second line at a lower temperature rise Maximum is reached at the same mol of barium hydroxide as the experiment with hydrochloric acid Some of the heat that would have been released is used to ionise the ethanoic acid	**[1]** **[1]** **[1]**
Qn2		**[Total: 15]**

Q# 44/ ALvl Chemistry/2015/s/TZ 1/ Paper 5/Q# 2/www.SmashingScience.org :o)

<table>
<tr><td>(b)</td><td>P1/P2</td><td>(Independent) Temperature
(Dependent) Concentration of magnesium methanoate</td><td>[1]</td></tr>
<tr><td>(c)</td><td>P3</td><td>Δ<i>H</i> is positive
(An increase in temperature) will favour / promote / increase / a movement in the direction of the endothermic change / reaction</td><td>[1]
[1]</td></tr>
<tr><td>(d)</td><td>P3</td><td>Precipitate is formed / barium sulfate is insoluble / insoluble product</td><td>[1]</td></tr>
<tr><td></td><td></td><td></td><td>[15]</td></tr>
<tr><td>2 (a) (i)</td><td>D1</td><td>$K_c = \frac{[HI]^2}{[H_2][I_2]}$</td><td>[1]</td></tr>
<tr><td>(ii)</td><td>D1</td><td>$K_c = \frac{4y^2}{(a-y)^2}$</td><td>[1]</td></tr>
<tr><td>(b) (i)</td><td>D3</td><td>
<table>
<tr><th>a mol dm^{–3}</th><th>a – y mol dm^{–3}</th><th>y mol dm^{–3}</th></tr>
<tr><td>0.200</td><td>0.022</td><td>0.178</td></tr>
<tr><td>0.500</td><td>0.050</td><td>0.450</td></tr>
<tr><td>0.800</td><td>0.252</td><td>0.548</td></tr>
<tr><td>1.000</td><td>0.200</td><td>0.800</td></tr>
<tr><td>1.500</td><td>0.365</td><td>1.135</td></tr>
<tr><td>2.100</td><td>0.570</td><td>1.530</td></tr>
<tr><td>2.800</td><td>0.652</td><td>2.148</td></tr>
<tr><td>3.400</td><td>0.700</td><td>2.700</td></tr>
<tr><td>3.800</td><td>0.867</td><td>2.933</td></tr>
<tr><td>4.200</td><td>0.868</td><td>3.332</td></tr>
<tr><td>4.900</td><td>1.150</td><td>3.750</td></tr>
</table>
All results for y are to 3 decimal places
All values for y are correct</td><td>[1]
[1]</td></tr>
<tr><td>(ii)</td><td>D1</td><td>All points plotted correctly</td><td>[1]</td></tr>
<tr><td>(iii)</td><td>E5</td><td>Appropriate straight line drawn through the origin</td><td>[1]</td></tr>
</table>

(c) (i)	**D3/C1**	Co-ordinates read correctly from the line Slope of the graph calculated correctly and given to **three significant figures** with no units.	[1] [1]
(ii)	**D3/C1**	Uses $\frac{\sqrt{K_c}}{2+\sqrt{K_c}}$ = gradient (value or y / a) and provides working Gives value of K_c	[1] [1]
(d)	**P4**	The hydrogen with air / oxygen is explosive at 760K / raised temperature	[1]
(e)	**E4**	Faster reaction / increased rate The value of K_c would be unaffected	[1] [1]
(f) (i)	**E4/C2**	The line drawn on the graph has a less steep gradient	[1]
(ii)		The equilibrium constant will be smaller	[1]
			[15]

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1 (a) (i)	M10	$HCOO^-(aq) \longrightarrow CO_2(g) + H^+(aq) + 2e^-$ $MnO_4^-(aq) + 8H^+(aq) + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$	[1] [1]
(ii)	M6	Magnesium methanoate is 1.312 mol dm^{-3} [$HCOO^-$(aq)] = 2.624 mol dm^{-3}	[1] [1]
(iii)	M6	Use <u>volumetric apparatus</u> (to measure 5.0 cm^3 / saturated (magnesium) methanoate solution). Make (the above) up to the mark (with water) in a 250 cm^3 volumetric / graduated flask	[1] [1]
(iv)	M3/P4	H^+ is needed for the reaction with manganite Provided the acid is in excess / sufficient / enough, the volume does not matter	[1] [1]
(v)	M5	A **<u>pale</u>** pink colour	[1]
(vi)	M10	0.051 mol dm^{-3}	[1]
(vii)	M10	1.28 mol dm^{-3}	[1]
(b)	P1/P2	(Independent) Temperature (Dependent) Concentration of magnesium methanoate	[1]
(c)	P3	ΔH is positive (An increase in temperature) will favour / promote / increase / a movement in the direction of the endothermic change / reaction	[1] [1]
(d)	P3	**Precipitate is formed** / barium sulfate is **insoluble** / **insoluble product**	[1]

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2	**(a)**	All plotted points correctly drawn	**1**	
		The best fit line should pass through or lie close to the first 10 points. (If all points do not lie on the line then the net deviation of the non-anomalous points on each side of the best fit line must be approximately the same.)	**1**	**[2]**
	(b)	The point at 12.00 cm^3 is an anomaly. (ECF from incorrect anomalous point.)	**1**	
		The sodium hydroxide has not been properly mixed with the acid **OR** insufficient sodium hydroxide was added.	**1**	**[2]**
	(c)	Indicator range between 6.5 and 11 for a minimum of 1 pH unit change.	**1**	**[1]**
	(d) (i)	Any **two** of the following: Na^+, A^-, HA	**1**	**[1]**
	(ii)	They will all have (nearly) the same concentration **OR** $A^- > Na^+ > HA$	**1**	
		Half of the HA has reacted with/been neutralised by/used up by the NaOH	**1**	**[2]**
	(e)	Reads correct value of pH from the graph drawn	**1**	
		Gives correct expression for K_a	**1**	
		Calculates K_a.	**1**	**[3]**
	(f) (i)	$[H^+] = 0.00389 \text{ mol dm}^{-3}$ **OR** $[H^+] = [A^-]$ ECF as (ans to $[H^+])^2$/(ans to **(e)**)	**1**	
		Calculates [HA] correctly based on the pH read from the graph	**1**	**[2]**
	(ii)	Conc of HA = 4 × 2.7 = 10.8 g dm^{-3} Relative molecular mass of HA = 10.8/ **2(f)(i)**	**1**	**[1]**
	(g)	Any appropriate error discussion e.g.: • many readings / measurements are taken each of which will have an error., • the H^+ from the water has been ignored, • no pH reading was taken at 15.00 cm^3, • H^+ is not exactly equal to A^- temperature varies during titration, • graph drawn by hand is not very accurate, • experiment not repeated.	**1**	**[1]**
			Total	**15**

Q# 47/ ALvl Chemistry/2006/w/TZ 1/ Paper 5/Q# 1/www.SmashingScience.org :o)

1 Give **one mark** if the temperature of solutions **FB 1** and **FB 2** and all maximum temperatures are recorded to one decimal place.
Withhold this mark if temperatures are recorded to 2 decimal places.

Give **one mark** if the average temperature, correct to 1 decimal place, has been calculated for **FB 1** and **FB 2** ***(do not penalise decimal places twice)***
and
the temperature rise for 0.07 mole (or 0.04 mole if appropriate) has been correctly calculated.

[2]

Accuracy

Record the Supervisor's standard, ringed, below the temperature rise box for experiment 2 (or experiment 5 if more appropriate).

Compare the candidate's temperature rise (corrected if necessary) for experiment 2 (or experiment 5 if more appropriate) with that obtained by the Supervisor.

Award marks as follows:

difference in ΔT / °C	mark
0 to 0.5	4
0.5+ to 1.0	3
1.0+ to 2.0	2
2.0+ to 3.0	1
Greater than 3.0	0

[4]

(a) Check the plotting of points for **0.08, 0.07, 0.04 and 0.03** mole of sodium hydroxide.

Give **two marks** if all four points have been correctly plotted.

Deduct one mark (no negative marks) for each point that has been incorrectly plotted.

Points that are on a vertical line of the grid (moles of NaOH) must be placed on the line – check the position of the centre of the cross or dot.

(Penalise an error in the precision of placing an otherwise correct point only once)
If uncertain about the position of the centre of a cross or dot check the other plotted points. Apply the penalty if there are two or more uncertainties

points on the y-axis (ΔT) should be plotted in the correct small square and within ½ small square of the position determined by the Examiner.

Also **deduct** from these two plotting marks (no negative marks) **one mark** for **each** of the following graphical errors:

- **(i)** moles of NaOH plotted on y-axis and ΔT plotted on the x-axis
- **(ii)** measured temperature (T) plotted instead of ΔT
- **(iii)** points are plotted in less than 4 large squares on either axis **or** an inappropriate scale has been selected.

[2]

(b) Give **one mark** if two straight lines have been drawn through the points and intersect. Accept two straight lines that meet (and stop) providing there is no free-hand drawing where the lines meet.

Do not give this mark if curves have been drawn.

If solutions have been carefully prepared there should be 3 points on each straight line with an end point between 0.05 and 0.06 mole of sodium hydroxide.

[1]

(c) Give **one mark** for correctly reading (correct to ½ small square) the moles of sodium hydroxide at the end-point from the graph.

Accept a value from the intersection of
any two straight lines **or**
curves **or**
the maximum of the graph if the two lines have been rounded.

[1]

(d) Give **one mark** for correctly calculating the volume of sulphuric acid at the end-point:

Reacting Quantities	
moles of NaOH	volume of H_2SO_4 / cm^3
0.08	10
0.07	15
0.06	20
0.05	25
0.04	30
0.03	35

[1]

Three ways of calculating the volume of H_2SO_4

(i) **Volume of H_2SO_4 = 50 - $\frac{40}{0.08}$ x moles NaOH from graph**

(ii) by inspection:

moles NaOH	**0.050**	0.052	0.054	0.056	0.058	**0.060**
Volume H_2SO_4 /cm^3	**25.00**	24.00	23.00	22.00	21.00	**20.00**

(iii) calculates the volume of sodium hydroxide

$\frac{\textbf{2.0 x volume}}{\textbf{1000}}$ **= moles NaOH from graph**, then calculates volume of H_2SO_4

volume of H_2SO_4 = 50 – volume of NaOH

(e) Give **one mark** for **ans (c) x $\frac{1}{2}$**

[1]

(f) Give **one mark** for **ans (e) x $\frac{1000}{\text{ans (d)}}$**

[1]

Enthalpy change

check and correct if necessary the subtractions in Table 1.3

calculate $\frac{\textbf{rise in temperature}}{\textbf{mass of FB 3}}$ correct to 1 decimal place

record the candidate's value alongside the Supervisor's value.

calculate, and record, the difference between the Supervisor and candidate.

Award accuracy marks as follows:

difference to Supervisor	mark
Up to 0.2	4
0.2+ to 0.4	3
0.4+ to 0.6	2
0.6+ to 1.0	1
Greater than 1.0	0

Deduct one mark from those awarded for accuracy (no negative marks) for **each** of the following:

(i) in Table 1.3, any **<u>mass measurement</u>** has not been recorded to at least two decimal places.
(This does not apply to a calculated mass of FB 3.)

(ii) there is a subtraction error in Table 1.3

[4]

(g) Give **one mark** for **50 x 4.3 x (<u>candidate's</u> temperature rise from Table 1.3) or**

$$\mathbf{50 \times 4.3 \times (\underline{\text{candidate's}}\ \text{temperature rise from Table 1.3}) \times \frac{1}{1000}}$$

[1]

(h) Give **one mark** for **<u>either</u>** of these expressions:

(i) **Moles of sodium hydroxide** = $\frac{\textbf{mass from Table 1.3}}{\textbf{40}}$

(ii) **Moles of sulphuric acid** = $\frac{50}{1000}$ **x concentration calculated in (f)** **<u>OR</u>**

Moles of sulphuric acid = $\frac{50}{1000}$ **x 1.5**

Give **one further mark** for both expressions and correct statement of the reagent in excess.

If (2 x moles of H_2SO_4) > moles of NaOH then H_2SO_4 is in excess.

If (2 x moles of H_2SO_4) < moles of NaOH then NaOH is in excess.

[2]

(i) Give **one mark** for the following:

If sulphuric acid is stated as in excess in **(h)**,

$$\frac{\text{ans (g)}}{\text{moles of NaOH from (h)}} \times \frac{1}{1000}$$

If sodium hydroxide is in excess in **(h)**,

$$\frac{\text{ans (g)}}{\text{moles of } H_2SO_4 \text{ from (h)}} \times \frac{1}{1000} \times \frac{1}{2}$$

Do not give this mark unless the numerical value is correctly in kJ.

Give **one mark** if a negative (-ve) sign is shown. *This is an independent mark.* **[2]**

There are 22 marking points in question 1.

Record the marks awarded and cancel any marks in excess of 20, recording 20 Max.

Q# 48/ ALvl Chemistry/2005/w/TZ 1/ Paper 5/Q# 2/www.SmashingScience.org :o)

2 Assessment of planning skills

(a) Outline Plan

Give **one mark** for mixing two pairs of solutions.
Do **not** give this mark if all three pairs have been mixed. **[1]**

Give **one mark** for stating that an acid/alkali pair will have a (large) temperature rise but an acid/acid pair will have no (or minimal) temperature change. **[1]**

Results

Give **one mark** for a suitable tabulation of results including units. **[1]**
Give **one mark** if one (or two) pair(s) show a significant temperature rise and one pair has virtually no temperature change
and
FB 5 is identified as the solution containing sodium hydroxide. **[1]**

(b) Give **one mark** for using twice the volume of sodium hydroxide compared to sulphuric acid. **[1]**

Give **one mark** for predicting that the temperature rise will be twice as great when 1.0 mol dm^{-3} sulphuric acid is used. **[1]**

Results

Give **one mark** for suitable tabulation of results.
Do **not** penalise absence of units if already penalised in **(a)**.
Give **one mark** if initial temperatures are recorded for each solution.
Give **one mark** if one pair has approximately twice the temperature rise of the other pair. **[3]**

Identity

Give **one mark** if the solutions are correctly identified.
FB 3 is 0.05 mol dm^{-3} H_2SO^4
FB 4 is 1.00 mol dm^{-3} H_2SO^4
FB 5 is 1.00 mol dm^{-3} NaOH

[Total for Question 2: 10 marks]