UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME

CENTRE NUMBER | | | | | |

CANDIDATE NUMBER | | | | |

2149935518

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **October/November 2011**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs, or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
You are advised to show all working in calculations.
Use of Data Booklet is unnecessary.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
Total	

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1 When potassium nitrate dissolves in water, the temperature of the solution goes down because the enthalpy of solution is endothermic.

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You are to plan an experiment to investigate how the solubility of potassium nitrate varies with temperature. The units of solubility are grams per one hundred grams of water (g / 100g water).

(a) (i) Predict how the solubility of potassium nitrate will change if the solution temperature is **increased**.

Explain your prediction using the fact that dissolving potassium nitrate is endothermic.

prediction .....

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explanation .....

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(ii) Display your prediction in the form of a sketch graph, labelling clearly the axes.

[3]

(b) In the experiment you are about to plan, identify the following.

(i) the independent variable .....

(ii) the dependent variable .....

[2]

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(c) Design a laboratory experiment to test your prediction in **(a)**.

In addition to the standard apparatus present in a laboratory you are provided with the following materials,

a boiling tube,
a looped wire stirrer,
a thermometer covering the temperature range 0 °C to 100 °C.

Describe how you would carry out the experiment. You should

- ensure a wide range of results suitable for analysis by graph,
- decide on the amounts of water and potassium nitrate to use,
- measure the amounts of the two reagents,
- heat the apparatus,
- decide at what point the temperature of the solution is to be taken.

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(d) State a hazard that must be considered when planning the experiment and describe precautions that should be taken to keep risks to a minimum.

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..... [1]

(e) Draw a table with appropriate headings to show the data you would record when carrying out your experiments and the values you would calculate in order to construct a graph to support or reject your prediction in **(a)**. The headings **must** include the appropriate units.

[2]

[Total: 15]

2 Chemical reactions occur more rapidly as the temperature of the reaction mixture increases. The mathematical relationship that summarises this is

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$$\log_{10}(\text{rate of reaction}) = \frac{-E_A}{19T}$$

where $\mathbf{E_A}$ is the **activation energy** of the reaction and **T** is the **absolute temperature** in Kelvin and the **rate of reaction** can be taken as the reciprocal of the time taken in seconds **(1/time)**.

An experiment was carried out to investigate this relationship using dilute hydrochloric acid and aqueous sodium thiosulfate.

- 20 cm^3 of dilute hydrochloric acid was placed in a boiling tube contained in a water bath.
- 20 cm^3 of aqueous sodium thiosulfate was added to the dilute hydrochloric acid, while stirring and a stopwatch started.
- The temperature of the water bath was recorded.
- After a period of time the liquid became cloudy (opaque) due to the formation of a precipitate of sulfur.
- As soon as this cloudiness (opacity) appeared the time was recorded.
- The temperature of the water bath was raised and the whole experiment repeated.

(a) The results of several such experiments are recorded below.

Process the results in the table to calculate **$\log_{10}$ (rate of reaction)**, the reciprocal of the absolute temperature (**1/T**) and the 'rate of reaction' (**1/time**). You should expect the values of **$\log_{10}$ (rate of reaction)** to be negative.

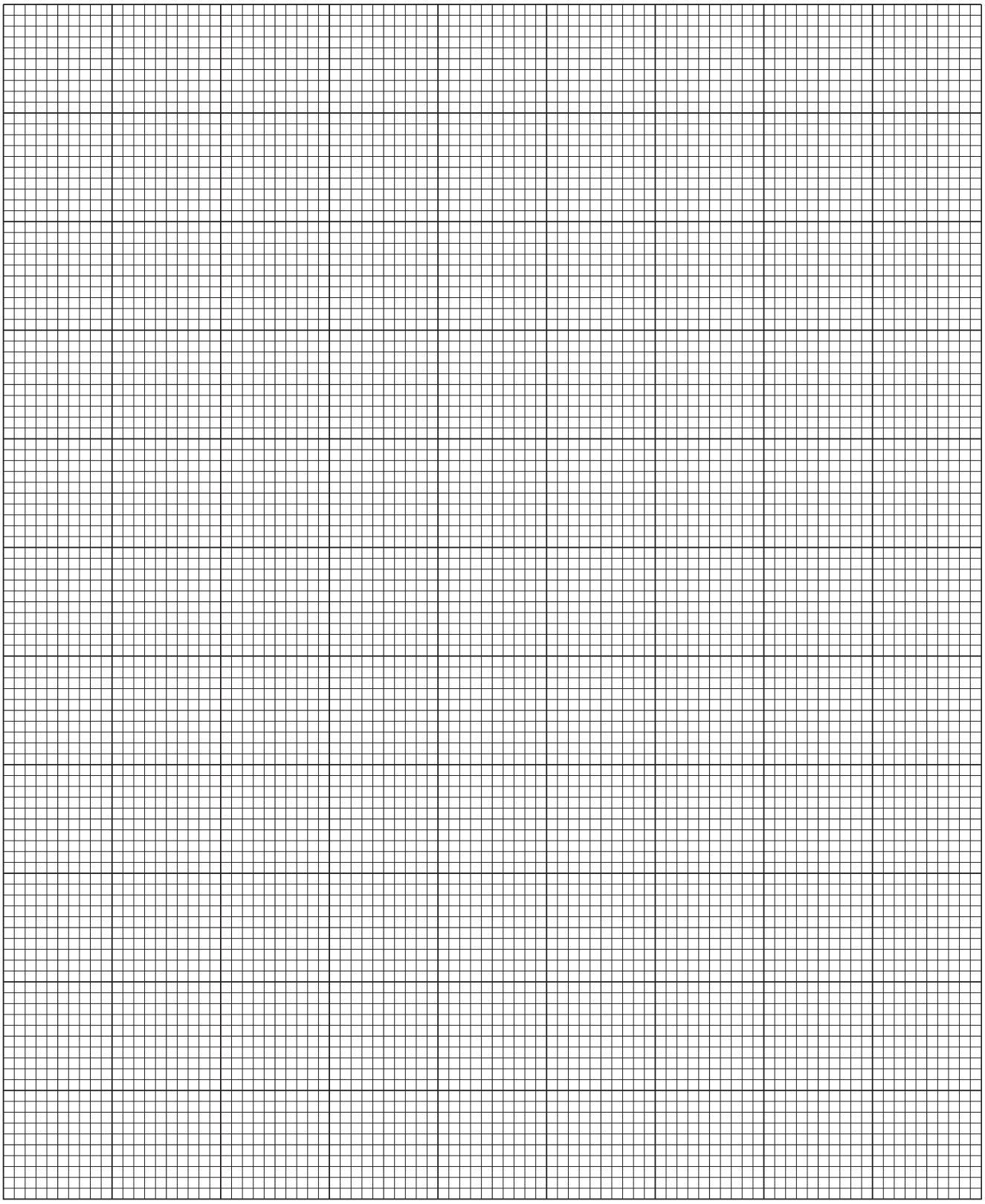
Record these values to **three significant figures** in the additional columns of the table.

Label the columns you use. For each column you use include units where appropriate and an expression to show how your values are calculated.

You may use the column headings A to F for these expressions (e.g. A–B). [3]

A	B	C	D	E	F
temperature / °C	absolute temperature / K	time / s			
20.0	293	60.3			
30.0	303	46.8			
40.0	313	41.6			
45.0	318	31.6			
50.0	323	28.8			
55.0	328	25.1			
60.0	333	21.0			
65.0	338	20.4			
70.0	343	18.1			
80.0	353	15.1			

(b) Plot a graph to show the relationship between **$\log_{10}$ (rate of reaction)** and the reciprocal of the absolute temperature. You are reminded that the values for **$\log_{10}$ (rate of reaction)** are negative.
Draw the line of best fit.



[3]

(c) Circle and label on the graph any point(s) you consider to be anomalous. For each anomalous point give a different reason why it is anomalous, clearly stating which point you are describing.

For Examiner's Use

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(d) Comment on whether the results obtained can be considered as reliable.

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(e) Determine the slope of the graph. Mark clearly on the graph any construction lines and show clearly in your calculation how the values from the intercepts were used in the calculation of the slope.

[2]

(f) Using the value of the slope of your graph calculated in **(f)** calculate a value for the **activation energy, E_A**. Correct use of the equation will produce an answer in $kJ\,mol^{-1}$.

[1]

(g) By considering the movement of particles in the reaction explain why the rate of reaction increases with increasing temperature.

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[2]

[Total: 15]

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7127397716

CHEMISTRY **9701/53**

Paper 5 Planning, Analysis and Evaluation **October/November 2011**

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1 If a container of gas has a tiny hole in it, the gas will gradually escape through the hole. This process is called **effusion** and the rate at which it occurs is called **the rate of effusion**.

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You are to plan an experiment to investigate how the **rate of effusion** depends on the **relative molecular mass**, M_r, of a gas.

(a) At a constant temperature, the rate of effusion of a gas depends on the kinetic energy of the molecules of the gas. So, for a series of gases all at the same temperature, as the M_r of a gas increases the speed of the molecules of the gas decreases.

(i) Predict how the rate of effusion will change as the M_r of the gas **increases**. Explain your prediction using the information in part **(a)** above.

prediction .....

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explanation .....

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(ii) Display your prediction in the form of a sketch graph below, clearly labelling the axes.

[3]

(b) In the experiment you are about to plan, identify the following.

(i) the independent variable .....

(ii) the dependent variable .....

[2]

(c) Using the apparatus shown below design a laboratory experiment to test your prediction in **(a)**.

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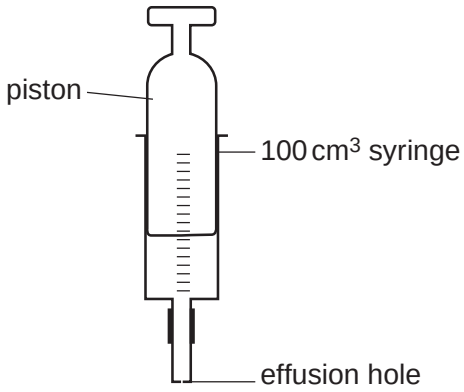

In addition to the standard apparatus present in a laboratory you are provided with the following materials,

- access to samples of the following gases; hydrogen, oxygen, carbon dioxide, butane and chlorine,
- a stop watch/clock.

Describe how you would carry out the experiment. You should

- ensure that the volume of gas measured is the same for each experiment,
- ensure that the syringe contains only the gas under investigation,
- ensure that the syringe is used under the same conditions throughout all of the experiments,
- measure the effusion time,
- produce reliable results.

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(d) State a hazard that must be considered when planning the experiment and describe precautions that should be taken to keep risks to a minimum.

For Examiner's Use

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(e) Draw a table with appropriate headings to show the data you would record when carrying out your experiments and the values you would calculate in order to construct a graph to support or reject your prediction in **(a)**. The headings **must** include the appropriate units. Ensure that the table covers all the detail relating to the five gases listed in **(c)**.

[A_r: H, 1.0; C, 12.0; O, 16.0; C*l*, 35.5]

[2]

[Total: 15]

2 There are three oxides of lead, PbO, PbO_2 and Pb_3O_4 all of which can be reduced to metallic lead by hydrogen. A sample of one of these oxides is reduced to find out which of the three oxides it is.

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An experiment was carried out as follows.

- An empty reduction tube was weighed and the mass recorded.
- A sample of the lead oxide was added to the reduction tube and the new mass recorded.
- The reduction tube and lead oxide was heated strongly for five minutes in a stream of hydrogen and then allowed to cool back to room temperature.
- The reduction tube and contents were then reweighed and the mass recorded.

(a) The results of several such experiments are recorded below.

[A_r: O, 16.0; Pb, 207.0]

Process the results in the table to calculate the number of moles of lead **atoms** and the number of moles of oxygen **atoms**.

Record these values in the additional columns of the table. You may use some or all of the columns. Label the columns you use.

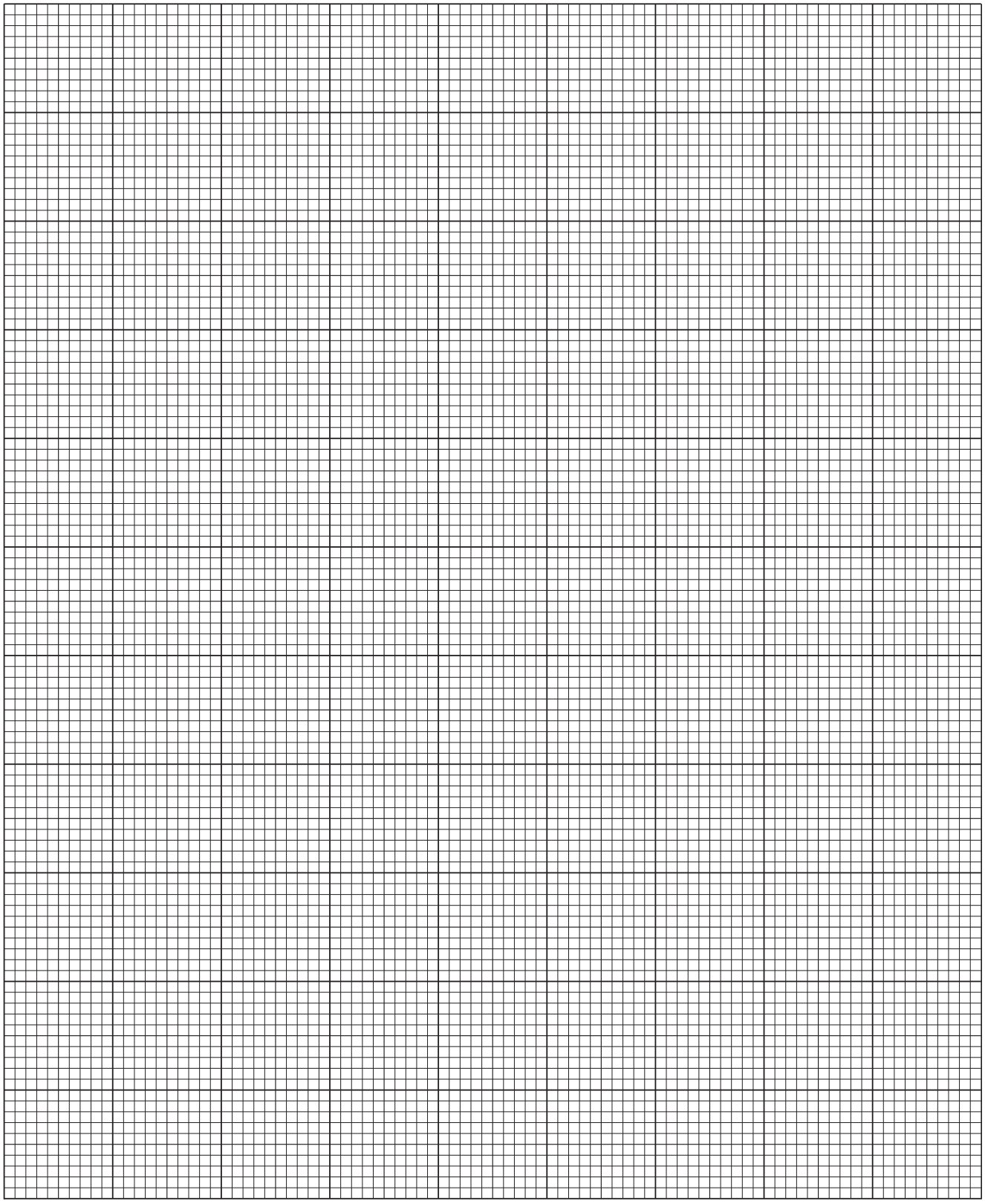
Masses should be recorded to **two decimal places** while the number of moles should be recorded to **two significant figures**.

For each column you use include units where appropriate and an expression to show how your values are calculated.

You may use the column headings A to G for these expressions (e.g. A–B). [3]

A	B	C	D	E	F	G
mass of reduction tube /g	mass of reduction tube + lead oxide /g	mass of reduction tube + lead /g				
9.90	14.95	14.48				
10.05	16.17	15.60				
10.25	17.92	17.21				
9.80	18.12	17.43				
9.60	18.43	17.61				
10.30	20.27	19.34				
11.05	22.05	21.03				
10.00	21.46	20.26				
9.75	24.07	22.74				
10.15	26.15	24.66				

(b) Plot a graph to show the relationship between the number of moles of oxygen **atoms** and the number of moles of lead **atoms**.
Draw the line of best fit.



[3]

(c) Circle and label on the graph any point(s) you consider to be anomalous. For each anomalous point give a different reason why it is anomalous, clearly stating which point you are describing.

For Examiner's Use

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(d) Comment on whether the results obtained can be considered as reliable.

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.....[1]

(e) Determine the slope of the graph. Mark clearly on the graph any construction lines and show clearly in your calculation how the values from the intercepts were used in the calculation of the slope.

[2]

(f) Comment on the value of the slope of the graph.
Deduce and explain the formula of the oxide investigated in this experiment.

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comment .....

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.....[3]

[Total: 15]

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