Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER | CANDIDATE NUMBER

2605952040

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2017**

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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a 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.

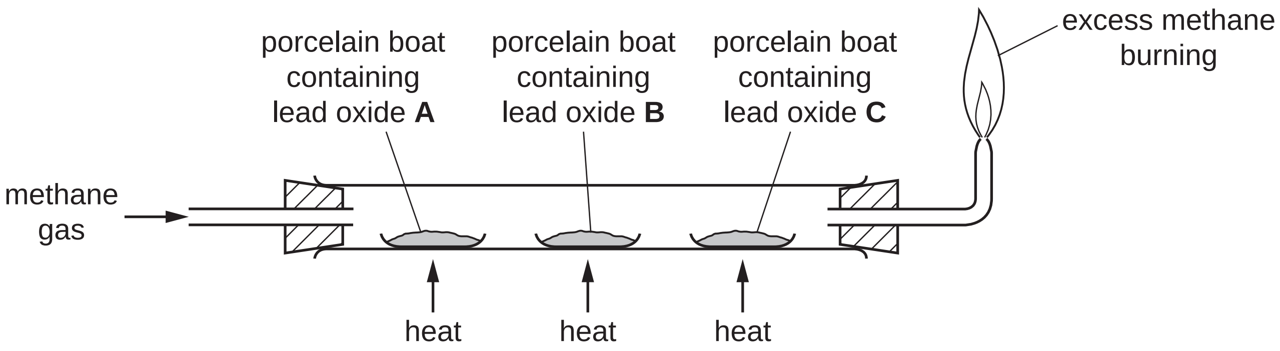
IB17 06_9701_52/4RP

CAMBRIDGE
International Examinations

1 In 1804 the chemist John Dalton put forward the following idea. It is sometimes called 'Dalton's Law'.

'When two elements combine with each other to form **more than one compound**, the ratios of the masses of one element that combine with a fixed mass of the other element are simple whole numbers.'

A student used the apparatus shown to find out if Dalton's Law is true for three oxides of lead. Methane gas reduced the heated lead oxides to lead.



Lead and oxides of lead are harmful by inhalation and if swallowed. They are very toxic to aquatic organisms and may cause long-term damage in the aquatic environment.

(a) State **two** hazards associated with experimenting with lead oxides.

For each hazard, state a precaution (other than eye protection) that the student could take to make sure that the experiment is carried out safely.

hazard 1 ....

precaution ....

....

hazard 2 ....

precaution ....

....
[2]

The student used the following procedure for the experiment.

- Three clean, dry porcelain boats were weighed when empty.
- Each boat was filled with a different lead oxide, labelled **A**, **B** or **C** and reweighed.
- The boats were placed in the apparatus and methane gas passed through.
- All three samples were heated strongly until they were reduced to lead.
- The boats were allowed to cool completely with the methane gas still passing over them before they were re-weighed.
- The results are shown in the table.

lead oxide	mass of porcelain boat / g	mass of boat + lead oxide / g	mass of boat + lead after heating / g	mass of lead / g	mass of oxygen / g	mass of lead that was combined with 1.0 g oxygen in the lead oxide / g
A	5.26	9.31	9.04			
B	5.12	8.96	8.48			
C	5.23	10.52	10.06			

(b) Complete the table. Record the mass of lead that was combined with 1.0 g of oxygen in the lead oxide to **one decimal place**.
Use the space below for any necessary calculations.

[2]

(c) **(i)** Use the values of mass of lead that was combined with 1.0 g oxygen in the lead oxide to calculate the ratio of mass of lead in each compound.

mass of lead in **A** : mass of lead in **B** : mass of lead in **C**

.... **:** .... **:** ....

[1]

(ii) If Dalton's Law is true there should be a **simple whole number ratio** of the masses of lead in each compound combined with a fixed mass of oxygen.

Use your answer to **(i)** to state and explain whether the student's experimental results support Dalton's Law.

....

.... [1]

(d) In this experiment, identify

the independent variable,

....

the dependent variable.

....

[2]

(e) **(i)** Another sample of lead oxide **B** was found to contain 3.067 g lead and 0.474 g oxygen.

Calculate the empirical formula of **B**. Show your working.
[A_r: Pb, 207.2; O, 16.0]

empirical formula of **B** = ... [1]

(ii) What additional piece of information is required to calculate the molecular formula of **B**?

.... [1]

(f) Before the porcelain boats containing the lead were weighed, they were allowed to cool completely with the methane gas still passing over them.

Apart from the hazards associated with handling hot apparatus, explain why this procedure is essential to ensure that the results are reliable.

....

.... [1]

(g) The student thought that not all of the lead oxide **C** had been reduced.

What should the student do to make sure all the lead oxide **C** had been reduced?

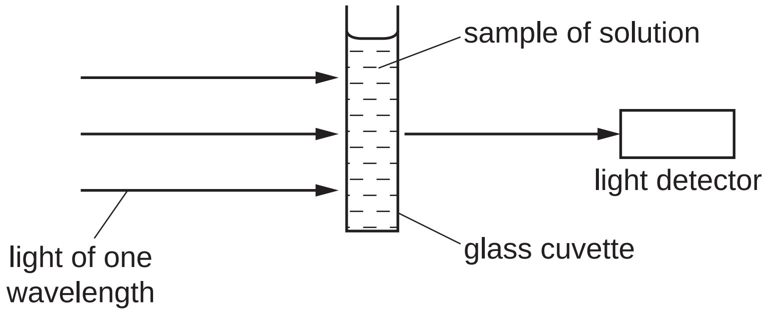
....

....

.... [1]

[Total: 12]

2 When light passes through solutions of chemical compounds some of the light may be absorbed. The quantity of light absorbed is called the absorbance and it is measured by a spectrophotometer. A simplified diagram of a spectrophotometer is shown. A glass cuvette is a rectangular vessel.



(a) (i) A chemist placed distilled water in the glass cuvette. This was then put into the spectrophotometer and a reading taken.

Explain why this reading was taken.

....

.... [1]

(ii) Light passes through opposite sides of the cuvette. These two sides must be wiped with a cloth to ensure they are clean and dry.

Explain why this procedure makes the readings more accurate.

....

.... [1]

Manganese is added to steel to increase its strength. A spectrophotometer can be used to analyse the manganese content of steel. This is done by comparing the absorbance of a solution of MnO_4^-(aq) prepared from a sample of steel, with the absorbance of solutions of known concentrations of MnO_4^-(aq).

(b) 1.0 dm^3 of a standard solution of 0.0300 $mol\,dm^{-3}$ MnO_4^- was prepared by a chemist using solid potassium manganate(VII), $KMnO_4$, measured using a two decimal place balance.

(i) Calculate the mass of $KMnO_4$ required to prepare this standard solution.
[A_r: K, 39.1; Mn, 54.9; O, 16.0]

mass of $KMnO_4$ = ... g [1]

(ii) Describe how the chemist should accurately prepare this standard solution using a sample of $KMnO_4$ of mass calculated in **(i)**. There is a 1.0 dm^3 volumetric flask available.

....

....

....

....

....

.... [2]

(iii) The chemist diluted this standard solution to 3.0×10^{-4} $mol\,dm^{-3}$ for use in the experiments.

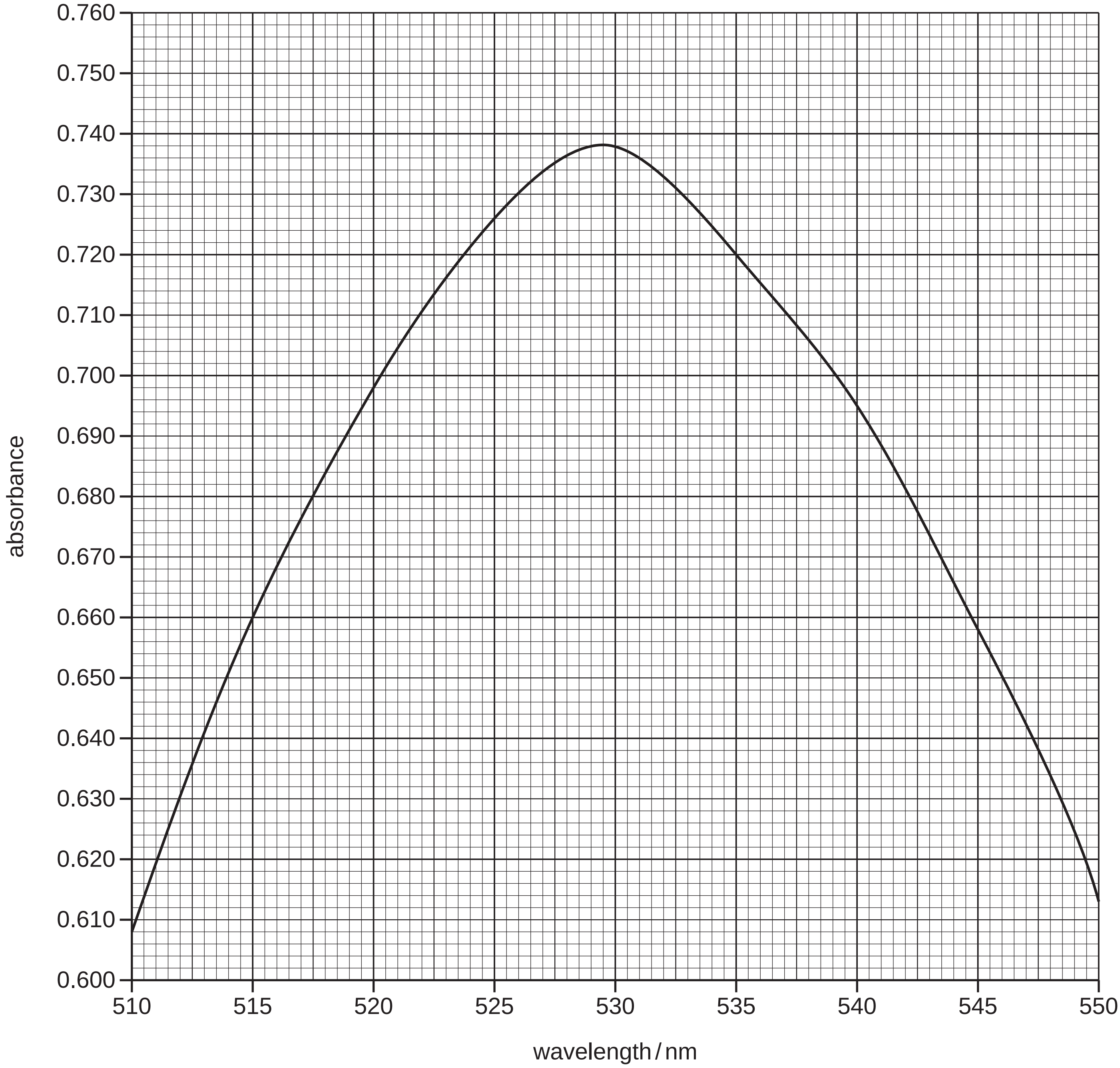
Explain why the chemist did not prepare a solution of this concentration directly, by dissolving the required mass of $KMnO_4$ in 1.0 dm^3 of water.

....

....

.... [1]

(c) The chemist needed to determine which wavelength of light was most absorbed by a solution of MnO_4^-(aq). The clean, dry cuvette was filled with 3.0×10^{-4} mol dm^{-3} MnO_4^- and different wavelengths of light were passed through the solution. A graph of the results was plotted.



Use the graph to estimate the wavelength of light that is most absorbed by the MnO_4^- solution.

wavelength of light most absorbed = ... nm [1]

Question 2 continues on the next page.

(d) The spectrophotometer was then set to the wavelength that is most absorbed by the MnO_4^-(aq) solution.

The chemist measured the absorbance of solutions of known concentrations of MnO_4^-(aq). The results are shown in the table.

concentration of MnO_4^-(aq) / mol dm^{-3}	absorbance
3.00×10^{-4}	0.748
2.70×10^{-4}	0.680
2.40×10^{-4}	0.610
2.10×10^{-4}	0.530
1.80×10^{-4}	0.440
1.50×10^{-4}	0.378
1.20×10^{-4}	0.315
0.90×10^{-4}	0.230
0.60×10^{-4}	0.150

(i) Plot a graph on the grid on page 11 to show the relationship between the absorbance and the concentration of MnO_4^-(aq).
Use a cross (×) to plot each data point. Draw a line of best fit. [2]

(ii) State the relationship between absorbance and concentration of MnO_4^-(aq). Explain your answer with reference to particles.

....

....

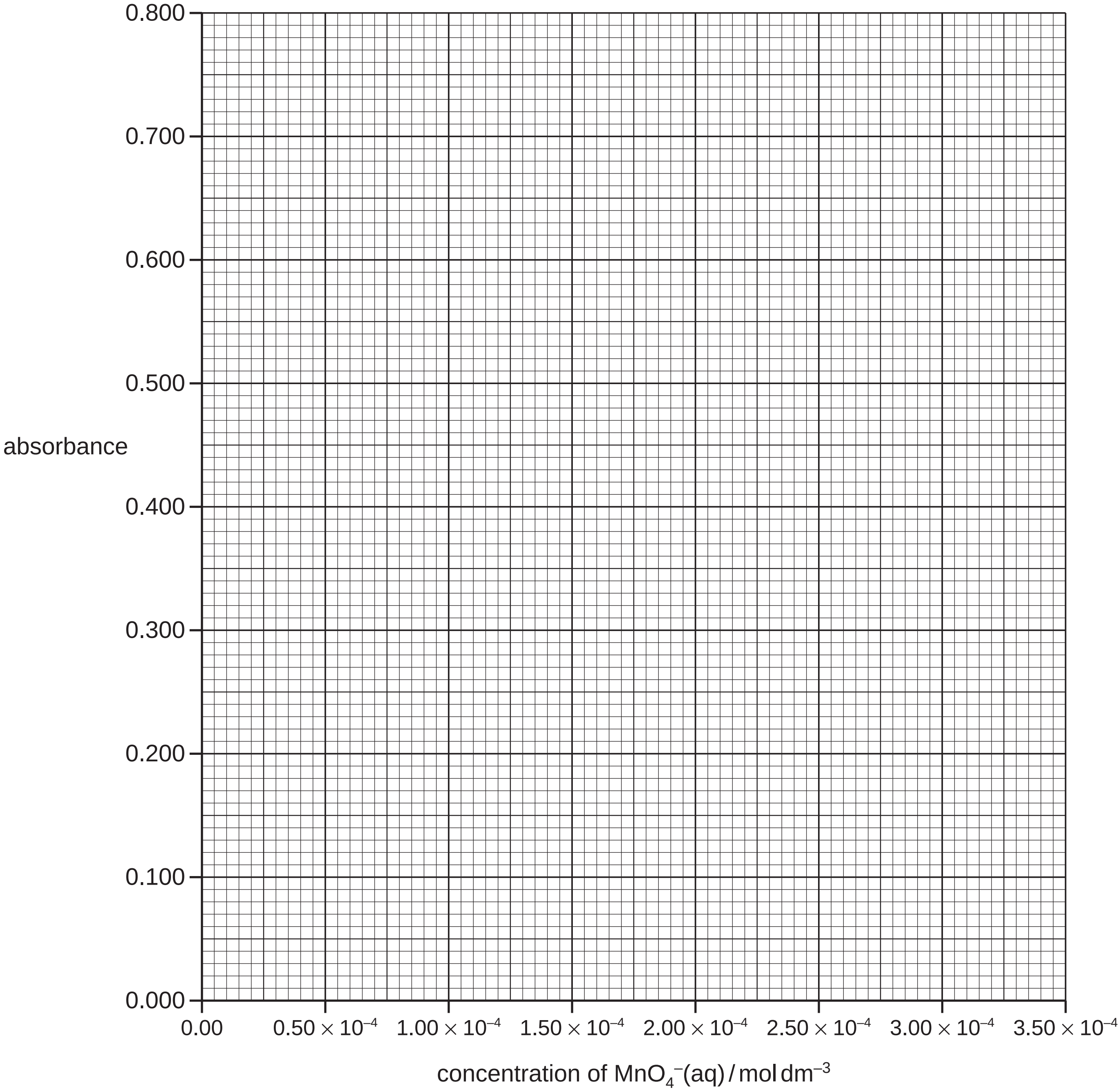
.... [2]

(iii) Do you consider the results obtained to be reliable? Explain your answer.

....

....

.... [1]


0.800
0.700
0.600
0.500
absorbance
0.400
0.300
0.200
0.100
0.000
0.00
0.50 × 10⁻⁴
1.00 × 10⁻⁴
1.50 × 10⁻⁴
2.00 × 10⁻⁴
2.50 × 10⁻⁴
3.00 × 10⁻⁴
3.50 × 10⁻⁴
concentration of MnO_4^-(aq) / mol dm^{-3}

(e) **(i)** The chemist used the MnO_4^-(aq) solution of concentration 3.00×10^{-4} mol dm^{-3} to prepare the solutions in the table on page 10.

Calculate the volume of 3.00×10^{-4} mol dm^{-3} MnO_4^-(aq) solution and the volume of distilled water required to prepare a 25.00 cm^3 solution of 2.70×10^{-4} mol dm^{-3} MnO_4^-(aq).
Give your answers to **two decimal places**.

volume of 3.00×10^{-4} mol dm^{-3} MnO_4^-(aq) solution = ... cm^3

volume of distilled water = ... cm^3
[1]

(ii) The volumes of the two solutions given in **(e)(i)** could be measured using the same type of apparatus.

Name a suitable piece of apparatus which could be used to measure these volumes.

.... [1]

The chemist dissolved a known mass of steel, containing manganese, in acid. The manganese was then oxidised to manganate(VII) ions, MnO_4^-, using a very strong oxidising agent. The resulting solution was made up to 100.0 cm^3 in a volumetric flask.

(f) A small sample of the solution of MnO_4^-(aq) prepared from the steel sample was placed into a clean, dry cuvette and its absorbance measured using the spectrophotometer.

(i) The absorbance of the MnO_4^-(aq) solution was 0.630.

Use the graph you have drawn in **(d)(i)** to determine the concentration of MnO_4^-(aq) in this solution.
Give your answer to **three significant figures**.

concentration of MnO_4^-(aq) = ... mol dm^{-3} [1]

(ii) Calculate the mass of manganese present in the steel sample. Show your working.
[A_r: Mn, 54.9]

mass of manganese = ... g [1]

(g) The steel sample that the chemist used had a mass of 1.209 g.

Use the mass of manganese you calculated in **(f)(ii)** to calculate the percentage of manganese by mass that was present in the steel sample.
(If you were unable to calculate an answer to **(f)(ii)** you may use 0.00143 g as the mass of manganese. This is not the correct answer.)

percentage of manganese in the steel sample = ... % [1]

(h) Another way of analysing the manganese content of the steel sample is by titration. The steel sample is prepared in the same way as previously. It is dissolved in acid and then oxidised using a very strong oxidising agent. The MnO_4^-(aq) ions produced are titrated with a solution of iron(II) ions. The equation for this reaction is shown.

$$MnO_4^-(aq) + 8H^+(aq) + 5Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$$

Explain why it is essential to remove the strong oxidising agent used to prepare the solution of steel sample before carrying out the titration.

....

.... [1]

[Total: 18]

BLANK PAGE

BLANK PAGE

BLANK PAGE