

Cambridge International Examinations

Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME		
CENTRE NUMBER	CANDIDATE NUMBER	
CHEMISTRY		9701/35

Paper 3 Advanced Practical Skills 1

October/November 2015

2 hours

Candidates answer on the Question Paper.

Additional Materials:

As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.

Give details of the practical session and laboratory where appropriate, in the boxes provided.

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.

A copy of the Periodic Table is printed on page 12.

Qualitative Analysis Notes are printed on pages 10 and 11.

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.

Session
Laboratory

For Examiner's Use		
1		
2		
3		
Total		

This document consists of 12 printed pages and 1 insert.



In this experiment you will determine the ionic equation for the reaction of acidified potassium manganate(VII) with potassium iodide. Excess potassium iodide is used and the reaction produces iodine. The amount of iodine produced is measured by titration with sodium thiosulfate.

FA 1 is 0.0180 mol dm⁻³ potassium manganate(VII), KMnO₄.

FA 2 is 1.00 mol dm⁻³ sulfuric acid, H₂SO₄.

FA 3 is 0.500 mol dm⁻³ potassium iodide, KI.

FA 4 is 0.100 mol dm⁻³ sodium thiosulfate, Na₂S₂O₃. starch indicator

(a) Method

- Pipette 25.0 cm³ of **FA 1** into a conical flask.
- Use the measuring cylinder to add 25 cm³ of **FA 2** to the conical flask.
- Use the measuring cylinder to add 20 cm³ of **FA 3** to the conical flask.
- Fill the burette with **FA 4**.
- Carry out a rough titration. When the colour of the mixture becomes yellow/orange, add a few drops of starch indicator. Then titrate until the mixture goes colourless.
- Record all your burette readings in the space below.

The rough titre is	S	cm ³
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- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record in a suitable form below all of your burette readings and the volume of FA 4 added in each accurate titration.

Keep FA 1 and FA 2 for use in Question 3 and FA 4 for use in Question 2.

I	
II	
III	
IV	
V	
VI	
VII	
[7]	

(b) From your accurate titration results, obtain a suitable value for the volume of **FA 4** to be used in your calculations.

Show clearly how you have obtained this value.

Volume of **FA 4** required is cm³. [1]

(c) Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(i) Calculate the number of moles of sodium thiosulfate in the volume of **FA 4** calculated in **(b)**.

moles of
$$Na_2S_2O_3$$
 = mol

(ii) Use the equation below to calculate the number of moles of iodine that reacted with the sodium thiosulfate in the titration.

$$I_2 + 2Na_2S_2O_3 \rightarrow Na_2S_4O_6 + 2NaI$$

moles of
$$I_2 = \dots \mod$$

(iii) Use information on page 2 to calculate the number of moles of potassium manganate(VII) in **FA 1** used in the titration.

moles of
$$KMnO_4 = \dots mol$$

(iv) From your answers to (ii) and (iii), calculate the number of moles of iodine produced by the reaction of **2.00** moles of potassium manganate(VII) with excess potassium iodide.

moles
$$I_2 = \dots mol$$

(v) Using your answer to (iv), put a tick next to the ionic equation that represents the reaction between FA 1 and FA 3.

$$2\mathsf{MnO_4^-} + 2\mathsf{I^-} + 16\mathsf{H^+} \ \rightarrow \ \mathsf{I_2} + 2\mathsf{Mn^{6+}} + 8\mathsf{H_2O} \qquad \dots \dots \dots$$

$$2 MnO_4^{-} \ + \ 4 I^{-} \ + \ 16 H^{+} \ \rightarrow \ 2 I_2 \ + \ 2 Mn^{5+} \ + \ 8 H_2 O \qquad$$

$$2MnO_4^- + 6I^- + 16H^+ \rightarrow 3I_2 + 2Mn^{4+} + 8H_2O$$

$$2MnO_4^- + 8I^- + 16H^+ \rightarrow 4I_2 + 2Mn^{3+} + 8H_2O$$

$$2MnO_4^- + 10I^- + 16H^+ \rightarrow 5I_2 + 2Mn^{2+} + 8H_2O$$

$$2MnO_4^- + 12I^- + 16H^+ \rightarrow 6I_2 + 2Mn^+ + 8H_2O$$

(vi)	Prove that the iodide ion has been oxidised in the equation that you selected in (v).
	[5]
(d) (i)	The error in calibration of the pipette you used is $\pm 0.06 \text{cm}^3$. Calculate the percentage error when measuring FA 1 , using the pipette.
	3 , 3 11
	percentage error = %
(ii)	A student suggested that the experiment would be more accurate if a pipette was used to measure solution FA 3 .
	State and explain whether you agree with the student.
	[2]
	[Total: 15]

2 In this experiment you will investigate how the rate of reaction between sodium thiosulfate and hydrochloric acid is affected by the concentration of the acid.

When aqueous thiosulfate ions react with hydrogen ions, H⁺, in any acid, a pale yellow precipitate of sulfur is formed. The ionic equation for this reaction is given below.

$$S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow S(s) + SO_2(aq) + H_2O(l)$$

The rate of the reaction can be determined by measuring the time taken to produce a fixed quantity of sulfur.

FA 4 is $0.10 \, \text{mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

FA 5 is 0.20 mol dm⁻³ hydrochloric acid, HC*l*.

(a) Method

Record **all** your measurements, in an appropriate form, in the space below.

Experiment 1

- Use the larger measuring cylinder to transfer 40 cm³ of **FA 4** into the 100 cm³ beaker.
- Rinse the larger measuring cylinder thoroughly with water, then add 30 cm³ of **FA 5** to the beaker and start timing **immediately**.
- Stir the mixture once and place the beaker on top of the printed insert page provided.
- Look down through the solution in the beaker at the print on the insert.
- Stop timing as soon as the precipitate of sulfur makes the print on the insert invisible.
- Record the reaction time to the nearest second.
- Empty and rinse the 100 cm³ beaker.
- Dry the outside of the beaker ready for Experiment 2.

Experiment 2

- Rinse the larger measuring cylinder, then use it to transfer 40 cm³ of **FA 4** into the 100 cm³ beaker.
- Use the smaller measuring cylinder to add 10 cm³ of distilled water to the beaker.
- Use the same measuring cylinder to add 20 cm³ of **FA 5** to the mixture in the beaker and start timing **immediately**.
- Stir the mixture once and place the beaker on top of the printed insert page provided.
- Stop timing as soon as the print on the insert becomes invisible.
- Record the reaction time to the **nearest second**.
- Empty and rinse the 100 cm³ beaker.
- Dry the outside of the beaker ready for Experiment 3.

Experiment 3

- Carry out the reaction using a mixture of 40 cm³ of **FA 4**, 20 cm³ of distilled water and 10 cm³ of **FA 5**.
- Measure and record the reaction time to the nearest second.

I	
II	
III	
IV	

[4]

(b) (i) The 'rate of reaction' can be represented by the formula below.

	'rate of reaction' = $\frac{1000}{\text{reaction time}}$
	Use this formula to calculate the 'rate of reaction' for Experiments 1 and 3. Give the unit.
	'rate of reaction' for Experiment 1 unit unit
	'rate of reaction' for Experiment 3 unit unit
(ii)	Calculate the initial concentrations of hydrochloric acid in the reaction mixtures in Experiments 1 and 3.
	initial concentration of HCl in Experiment 1 = moldm
	initial concentration of HC1 in Experiment 3 = mol dm
(iii)	How is the 'rate of reaction' affected by the concentration of hydrochloric acid in the mixture?
(iv)	Predict how the reaction time measured in Experiment 1 would have been affected if the experiment had been carried out using 0.20 mol dm ⁻³ sulfuric acid instead of 0.20 mol dm ⁻¹ hydrochloric acid. Explain your answer.
(v)	Predict how the reaction time measured in Experiment 3 would have been affected if the experiment had been carried out in a 250 cm³ beaker instead of a 100 cm³ beaker. Explain your answer.
	[5

3 Qualitative Analysis

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations**.

You should indicate clearly at what stage in a test a change occurs. No additional tests for ions present should be attempted.

If any solution is warmed, a boiling tube MUST be used.

Rinse and reuse test-tubes and boiling tubes where possible.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

(a) FA 6 is a sodium compound containing one anion listed on page 11.

Dissolve the **FA 6** provided in about 15 cm³ of distilled water in a boiling tube. Carry out the following tests and record your observations in the table below.

	test	observations
(i)	To a 1cm depth of the solution of FA 6 in a test-tube, add a few drops of aqueous barium chloride or aqueous barium nitrate, then	
	add dilute hydrochloric acid.	
(ii)	To a 1cm depth of the solution of FA 6 in a test-tube, add an equal volume of aqueous hydrogen peroxide, then	
	add a few drops of aqueous barium chloride or aqueous barium nitrate, then	
	add dilute hydrochloric acid.	

	test	observations
(iii)	To a 1 cm depth of the solution of FA 6 in a boiling tube, add an equal volume of FA 2 , sulfuric acid, then	
	heat the mixture gently and cautiously.	
(iv)	To a 1 cm depth of the solution of FA 6 in a test-tube, add an equal volume of aqueous sodium hydroxide, then	
	add a few drops of FA 1 , aqueous potassium manganate(VII), then	
	add FA 2 , sulfuric acid.	

(v)	Identify the anion in FA 6, and state one piece of evidence for your identification.
	anion
	evidence
(vi)	Give the chemical equation for the reaction between FA 6 and hydrogen peroxide, H_2O_2 in test (ii). State symbols are not required.
	[7]

(b) FA 7, FA 8, FA 9 and FA 10 each contain one cation from the list on page 10.

You will attempt to identify the cations by testing with aqueous sodium hydroxide and aqueous ammonia.

In each case, use a 1 cm depth of the solution in a test-tube.

(i) Complete the table below.

toot	observations				
test	FA 7	FA 8	FA 9	FA 10	
add sodium hydroxide					
add aqueous ammonia					

(11)	Use your observations to identify, as far as possible, the cation present in each solution. If alternative identities are possible, state this clearly.
	FA 7 cation
	FA 8 cation
	FA 9 cation
	FA 10 cation
(iii)	Give the ionic equation for the reaction of one of your cations with a few drops of sodium hydroxide. State symbols are not required.
(iv)	The precipitates obtained when alkalis are added to solutions of certain cations are sometimes difficult to see. Suggest how, using no additional apparatus, the experiment could be repeated in a way that would make these precipitates more visible.
	[9]

[Total: 16]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	reaction with					
ion	NaOH(aq)	NH ₃ (aq)				
aluminium, Al³+(aq)	white ppt. soluble in excess	white ppt. insoluble in excess				
ammonium, NH₄⁺(aq)	no ppt. ammonia produced on heating	_				
barium, Ba ²⁺ (aq)	no ppt. (if reagents are pure)	no ppt.				
calcium, Ca ²⁺ (aq)	white ppt. with high [Ca ²⁺ (aq)]	no ppt.				
chromium(III), Cr³+(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess				
copper(II), Cu ²⁺ (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution				
iron(II), Fe²+(aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess				
iron(III), Fe³+(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess				
magnesium, Mg ²⁺ (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess				
manganese(II), Mn ²⁺ (aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess				
zinc, Zn ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess				

2 Reactions of anions

ion	reaction				
carbonate, CO ₃ ²⁻	CO ₂ liberated by dilute acids				
chloride, C <i>l</i> ⁻ (aq)	gives white ppt. with Ag ⁺ (aq) (soluble in NH ₃ (aq))				
bromide, Br ⁻ (aq)	gives cream ppt. with Ag ⁺ (aq) (partially soluble in NH ₃ (aq))				
iodide, I ⁻ (aq)	gives yellow ppt. with Ag ⁺ (aq) (insoluble in NH ₃ (aq))				
nitrate, NO ₃ -(aq)	NH ₃ liberated on heating with OH ⁻ (aq) and A <i>l</i> foil				
nitrite, NO ₂ ⁻ (aq)	NH_3 liberated on heating with $OH^-(aq)$ and Al foil; NO liberated by dilute acids (colourless $NO \rightarrow$ (pale) brown NO_2 in air)				
sulfate, SO ₄ ²⁻ (aq)	gives white ppt. with Ba ²⁺ (aq) (insoluble in excess dilute strong acids)				
sulfite, SO ₃ ²⁻ (aq)	SO ₂ liberated with dilute acids; gives white ppt. with Ba ²⁺ (aq) (soluble in excess dilute strong acids)				

3 Tests for gases

gas	test and test result			
ammonia, NH ₃	turns damp red litmus paper blue			
carbon dioxide, CO ₂	gives a white ppt. with limewater (ppt. dissolves with excess CO ₂)			
chlorine, Cl ₂	bleaches damp litmus paper			
hydrogen, H ₂	"pops" with a lighted splint			
oxygen, O ₂	relights a glowing splint			
sulfur dioxide, SO ₂	turns acidified aqueous potassium manganate(VII) from purple to colourless			

The Periodic Table of the Elements

	0	4.0 H elium	20.2 Ne 0n	39.9 Ar Argon	83.8 Kr Krypton	131 Xe Xenon	Radon	Uuo Ununoctium 118	175 Lu Lutetium	Lr Lawrendum 103
		~ ± ×	6	18	×	24 2 × ×	98	D Unu 811		
Group	=		19.0 T Fluorine	35.5 C1 Chlorine	79.9 Br Bromine 35	127 	At Astatine 85		173 Yb Ytterbium	Nobelium
	5		16.0 Oxygen	32.1 Suffur 16	79.0 Se Selenium 34	128 Te Tellurium	Po Potonium 84	Ununhexium 116	169 T m Thulium	Md Mendelevium
	>		14.0 N itrogen	31.0 P Phosphorus	74.9 AS Arsenic 33	122 Sb Antimony 51	209 Bi Bismuth 83		167 Er bium 68	Fm Fermium
	≥		12.0 C Carbon	28.1 Si Silicon	72.6 Ge Germanium 32	119 S	207 Pb Lead	Uuq Unuquadium	165 Ho Holmium 67	Einsteinium
	≡		10.8 Boron	27.0 A1 Aluminium	69.7 Ga Gallium 31	115 n Indium	204 T 1 Thallium		163 Dy Dysprosium 66	Cf Californium
					65.4 Zn Zinc	112 Cd Cadmium 48	201 Hg Mercury	Uub Ununbium 112	159 Tb Terbium	Bk Berkelium 97
					63.5 Cu Copper	108 Ag Silver 47	197 Au Gold	Unununium 111	157 Gd Gadolinium 64	Cm Curium
					58.7 N ickel	106 Pd Palladium	195 Pt Platinum 78	Ununnilium 110	152 Eu Europium 63	Am Americium
			1		58.9 Co Cobalt 27	Rhodium 45	192 r ridium	Mt Meitnerium 109	Samarium 62	Pu Plutonium
		1.0 T Hydrogen			55.8 Fe Iron	Ruthenium 44	190 Os Osmium 76	Hassium 108	Pm Promethium 61	Neptunium
					54.9 Mn Manganese	Tc Technetium 43	186 Re Rhenium 75	Bh Bohrium 107	144 Nd Neodymium 60	U Uranium
					52.0 Cr Chromium 24	95.9 Molybdenum 42	184 W Tungsten 74	Sg Seaborgium 106	Praseodymium 59	Pa Protactinium
					50.9 Vanadium 23	92.9 Nb Niobium	181 Ta Tantalum 73	Db Dubnium 105	140 Ce rium 58	Th Thorium
					47.9 T Titanium	91.2 Zr Zirconium 40	178 H Hatnium 72	Rutherfordium	*	nic mass † bol nic) number
				1	Scandium 21	88.9 ×	139 La Lanthanum *	Actinium teges	Š	 a = relative atomic mass † X = atomic symbol b = proton (atomic) number
	=		9.0 Be Beryllium	Mg Magnesium	40.1 Ca Calcium	87.6 Sr Strontium	137 Ba Barium 56	Radium 88	*58-71 Lanthanides	« × °
	_		6.9 Lithium	23.0 Na Sodium	39.1 K Potassium 19	85.5 Rb Rubidium 37	133 Cs Caesium 55	Francium 87	*58-71L 190-103,	Key

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