



GAN ENG SENG SCHOOL
Preliminary Examination 2024



**CANDIDATE
NAME**

CLASS

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**INDEX
NUMBER**

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CHEMISTRY

Paper 3

6092/03

5 August 2024

1 hour 50 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name on all the work you hand in.

Give details of the practical shift 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, highlighters, glue or correction fluid/tape.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

Qualitative analysis notes are printed on page **12**.

The Periodic Table is provided on page **13**.

The number of marks is given in brackets [] at the end of each questions or part question.

Shift	
Laboratory	
For Examiner's Use	
Q1	17
Q2	18
Q3	5
Total	40

- 1 Sodium carbonate reacts with dilute sulfuric acid. This reaction is exothermic.

In this experiment you will determine the percentage purity of a sample of impure anhydrous sodium carbonate. You will measure the enthalpy change of reaction when a sample of impure anhydrous sodium carbonate reacts with excess dilute sulfuric acid.

Read all the instructions carefully before starting the experiments in Question 1.

Instructions

X is a sample of the impure anhydrous sodium carbonate.

Y is 1.00 mol/dm³ dilute sulfuric acid, H₂SO₄

- (a) • Weigh the container with **X**. Record this mass.

mass of container with **X** = g

- Support the Styrofoam cup in the 250 cm³ beaker.
- Use the measuring cylinder to place 25 cm³ of **Y** into the cup.
- Measure the temperature of **Y**. Record this temperature at time = 0 in the table below.
- Start the stopwatch and leave it running for the whole experiment.
- Measure the temperature of **Y** every minute for 2 minutes. Record the temperatures in the table below.
- At 3 minutes transfer **X** from the container into the cup. Stir the contents and continue to measure, and record, the temperature every minute up to 8 minutes.

Results

time/min	0	1	2	3	4	5	6	7	8
temperature/°C									

- Reweigh the container with any residual solid. Record this mass.

mass of container with residual **X** = g

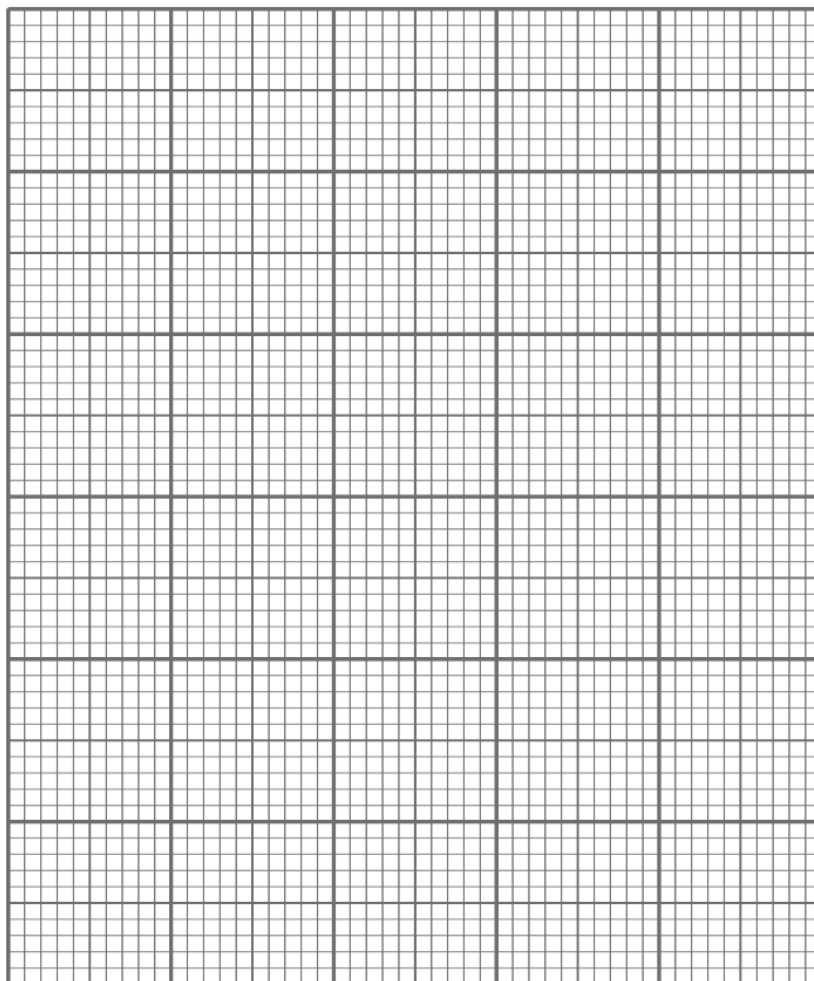
[3]

- (b) (i) Plot your results on the grid with temperature on the y-axis and time on the x-axis.

Complete the graph by drawing **two** straight lines of best fit. One line should be drawn using data from 0 to 2 minutes and the other line should be drawn using data from 4 to 8 minutes.

Extend both of these lines to 3 minutes.

Draw a vertical line at 3 minutes to connect these lines.



[4]

- (ii) Use your lines from (b)(i) to calculate the maximum temperature **rise** in the experiment.

maximum temperature rise = °C [1]

- (c) (i) The amount of heat released in this experiment can be calculated using the expression shown.

heat released (in J) = mass of solution (in g) \times maximum temperature rise (in $^{\circ}\text{C}$) \times 4.2

Use this expression to calculate, in J, the amount of heat released.

Assume that 1.0 cm^3 of solution has a mass of 1.0 g.

amount of heat released = J [1]

- (ii) The equation for the reaction between anhydrous sodium carbonate and sulfuric acid is shown.



A textbook lists the enthalpy change of this reaction as -40.0 kJ/mol .

Use this figure, and the value that you found in (c)(i), to find the mass of anhydrous sodium carbonate you used in (a). You should assume that no heat was lost to the surroundings in your experiment.

[M_r : Na_2CO_3 , 106]

mass of Na_2CO_3 = g [2]

- (iii) Calculate the percentage of anhydrous sodium carbonate present in X.

percentage Na_2CO_3 in X = % [2]

- (d) In your calculation in (c), what assumption have you made about the impurity present in **X**?

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[1]

- (e) Another student carries out the same experiment but only measures the initial temperature of the solution and the highest temperature reached in order to calculate the temperature rise.

Suggest why the student who uses a graph to calculate the temperature rise is able to obtain a more accurate value for the amount of heat released.

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[1]

- (f) A student decided to confirm by experiment the literature value for the enthalpy change of the reaction between anhydrous sodium carbonate and sulfuric acid. By mistake the student weighed a sample of hydrated sodium carbonate, $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$, instead of anhydrous sodium carbonate, Na_2CO_3 .

State what effect this would have on the calculated value of the enthalpy change for the reaction. Explain your answer.

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[2]

[Total: 17]

- 2 You are to determine, by titration, the change in oxidation number of a transition metal ion, M^{2+} , when reacted with acidified potassium manganate(VII).

Read all the instructions carefully before starting the experiments in Question 2.

Instructions

P is 0.0200 mol/dm^3 potassium manganate(VII), $KMnO_4$.

Q is 0.0795 mol/dm^3 transition metal salt, MSO_4 .

Y is 1.00 mol/dm^3 sulfuric acid, H_2SO_4

- (a) Put **P** into the burette.

The colour of **P** makes it difficult to see the bottom of the meniscus so you should take all your readings using the top of the meniscus.

Pipette a 25.0 cm^3 portion of **Q** into a conical flask. To the solution in the flask also add about 25 cm^3 of **Y** using a measuring cylinder.

Add **P** from the burette. At first the purple colour disappears quickly but as more **P** is added the colour disappears less quickly. At the end-point, one drop of **P** produces a pale pink colour that does not disappear on swirling.

Record your results in the table, repeating the titration as many times as you consider necessary to achieve consistent results.

Result

[5]

- (b) From your titration results, obtain an average volume of **P** to be used in your calculations. Show clearly how you obtained this volume.

average volume of **P** = [1]

- (c) (i) Calculate the number of moles of potassium manganate(VII) present in the average volume of **P** required.

number of moles of potassium manganate(VII) = mol [1]

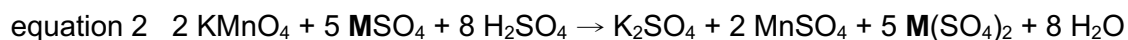
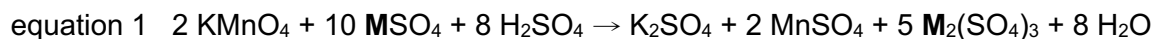
- (ii) Calculate the number of moles of **MSO₄** in 25.0 cm³ of **Q**.

number of moles of **MSO₄** in 25.0 cm³ = mol [1]

- (iii) Use your answers to (c)(i) and (c)(ii) to calculate the number of moles of **MSO₄** that react with 1 mole of **KMnO₄**.

number of moles of **MSO₄** = mol [2]

- (iv) Two possible equations for the reaction of acidified **KMnO₄** with **M²⁺** are shown below.



State and explain which of these two equations is consistent with your answer to (c)(iii).

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[1]

- (d) Aqueous solutions of M^{2+} ions readily undergo oxidation in air.

State the effect, on your answer in (c)(iii), if some of your sample of **Q** had oxidised before you carried out the titration.

Explain your answer.

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..... [3]

- (e) You are provided with a solid sample of an organic compound **R** in a boiling tube.

Add about 5 cm depth of deionised water to sample in the boiling tube. Shake the mixture. This solution is **R(aq)**.

Carry out the following tests. Record all your observations in the table.

test	observations
Test 1 Put about 2 cm depth of R(aq) in a test-tube. Then add a 2 to 3 drops of Universal Indicator solution.	[1]
Test 2 Put about 2 cm depth of R(aq) in a test-tube. Add an equal volume of Y . Then add 2 to 3 drops of solution P .	[1]

- (f) (i) From your observations in part (e), deduce the identity of a cation in $\mathbf{R(aq)}$.

Explain your deduction using evidence from your observations.

cation is

explanation

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[1]

- (ii) The role played by $\mathbf{R(aq)}$ may be either that of an oxidising agent or of a reducing agent.

Deduce the role played by $\mathbf{R(aq)}$ in Test 2.

Explain your deduction using evidence from your observations.

role played by \mathbf{R}

explanation

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[1]

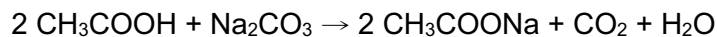
[Total: 18]

3 Planning

Vinegar is a solution of ethanoic acid in water.

The concentration of ethanoic acid in vinegar can be determined by reaction with **solid** sodium carbonate and measuring the volume of carbon dioxide produced.

The equation for the reaction is shown.



Use this information to outline a method to determine the concentration of the vinegar solution.

Your method should use gas collection by the **displacement of water**.

In your method you should include:

- the apparatus you would use
- the measurements you would take
- an explanation of how you would use your results to determine the concentration of ethanoic acid (in mol/dm³) of the vinegar sample
- any assumptions you have made

You can assume that the apparatus and reagents normally found in a school laboratory are available.

You may wish to use a labelled diagram to illustrate your answer.

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[5]

End of Paper

QUALITATIVE ANALYSIS NOTES

Test for anions

anion	test	test result
carbonate (CO_3^{2-})	add dilute acid	effervescence, carbon dioxide produced
chloride (Cl^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
iodide (I^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	yellow ppt.
nitrate (NO_3^-) [in solution]	add aqueous sodium hydroxide, then aluminium foil; warm carefully	ammonia produced
sulfate (SO_4^{2-}) [in solution]	acidify with dilute nitric acid, then add aqueous barium nitrate	white ppt.

Test for aqueous cations

cation	effect of aqueous sodium hydroxide	effect of aqueous ammonia
aluminium (Al^{3+})	white ppt., soluble in excess giving a colourless solution	white ppt., insoluble in excess
ammonium (NH_4^+)	ammonia produced on warming	—
calcium (Ca^{2+})	white ppt., insoluble in excess	no ppt.
copper(II) (Cu^{2+})	light blue ppt., insoluble in excess	light blue ppt., soluble in excess giving a dark blue solution.
iron(II) (Fe^{2+})	green ppt., insoluble in excess	green ppt., insoluble in excess
iron(III) (Fe^{3+})	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc (Zn^{2+})	white ppt. soluble in excess giving a colourless solution	white ppt. soluble in excess giving a colourless solution

Test for gases

gas	test and test result
ammonia (NH_3)	turns a 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 aqueous acidified potassium manganate(VII) from purple to colourless

The Periodic Table of Elements

Group																				
1	2													13	14	15	16	17	18	
		<div>1 H hydrogen 1</div>																		
		<div>Key</div> <div>proton (atomic) number atomic symbol name relative atomic mass</div>																		
3	4																			
Li	Be																			
lithium	beryllium																			
7	9																			
11	12																			
Na	Mg																			
sodium	magnesium																			
23	24																			
3		4	5	6	7	8	9	10	11	12										
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36			
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr			
potassium	calcium	scandium	titanium	vanadium	chromium	manganese	iron	cobalt	nickel	copper	zinc	gallium	germanium	arsenic	selenium	bromine	krypton			
39	40	45	48	51	52	55	56	59	59	64	65	70	73	75	79	80	84			
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54			
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe			
rubidium	strontium	yttrium	zirconium	niobium	molybdenum	technetium	ruthenium	rhodium	palladium	silver	cadmium	indium	tin	antimony	tellurium	iodine	xenon			
85	88	89	91	93	96	—	101	103	106	108	112	115	119	122	128	127	131			
55	56	57–71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86			
Cs	Ba	lanthanoids	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn			
caesium	barium		hafnium	tantalum	tungsten	rhenium	osmium	iridium	platinum	gold	mercury	thallium	lead	bismuth	polonium	astatine	radon			
133	137		178	181	184	186	190	192	195	197	201	204	207	209	—	—	—			
87	88	89–103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118			
Fr	Ra	actinoids	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og			
francium	radium		rutherfordium	dubnium	seaborgium	bohrium	hassium	meitnerium	darmstadtium	roentgenium	copernicium	nihonium	flerovium	moscovium	livermorium	tennessine	oganesson			
—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—			
lanthanoids		57	58	59	60	61	62	63	64	65	66	67	68	69	70	71				
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu				
		lanthanum	cerium	praseodymium	neodymium	promethium	samarium	euporium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium	lutetium				
		139	140	141	144	—	150	152	157	159	163	165	167	169	173	175				
actinoids		89	90	91	92	93	94	95	96	97	98	99	100	101	102	103				
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr				
		actinium	thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendelevium	nobelium	lawrencium				
		—	232	231	238	—	—	—	—	—	—	—	—	—	—	—				

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).

The Avogadro constant, $L = 6.02 \times 10^{23} \text{ mol}^{-1}$