GAN ENG SENG SCHOOL
Preliminary Examination 2024

CANDIDATE NAME	

CLASS			**INDEX NUMBER**	

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/dm^3 dilute sulfuric acid, H_2SO_4

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

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

- Support the Styrofoam cup in the 250 cm^3 beaker.
- Use the measuring cylinder to place 25 cm^3 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/ºC									

- 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 = ... ºC [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) × maximum temperature rise (in °C) × 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.

$$Na_2CO_3(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + H_2O(l) + CO_2(g)$$

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, $Na_2CO_3 \bullet 10H_2O$, 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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[Total: 17]

2 You are to determine, by titration, the change in oxidation number of a transition metal ion, $\mathbf{M}^{2+}$, 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, $\mathbf{M}SO_4$.
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 **M**SO_4 in 25.0 cm^3 of **Q**.

number of moles of **M**SO_4 in 25.0 cm^3 = ... mol [1]

(iii) Use your answers to **(c)(i)** and **(c)(ii)** to calculate the number of moles of **M**SO_4 that react with 1 mole of $KMnO_4$.

number of moles of **M**SO_4 = ... mol [2]

(iv) Two possible equations for the reaction of acidified $KMnO_4$ with $\mathbf{M}^{2+}$ are shown below.

equation 1 $2\ KMnO_4 + 10\ \mathbf{M}SO_4 + 8\ H_2SO_4 \rightarrow K_2SO_4 + 2\ MnSO_4 + 5\ \mathbf{M}_2(SO_4)_3 + 8\ H_2O$

equation 2 $2\ KMnO_4 + 5\ \mathbf{M}SO_4 + 8\ H_2SO_4 \rightarrow K_2SO_4 + 2\ MnSO_4 + 5\ \mathbf{M}(SO_4)_2 + 8\ H_2O$

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

....

.... [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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(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 **R**(aq).

Explain your deduction using evidence from your observations.

cation is ....

explanation ....

....

.... [1]

(ii) The role played by **R**(aq) may be either that of an oxidising agent or of a reducing agent.

Deduce the role played by **R**(aq) in Test 2.

Explain your deduction using evidence from your observations.

role played by **R** ....

explanation ....

....

.... [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.

$$2\ CH_3COOH + Na_2CO_3 \rightarrow 2\ CH_3COONa + CO_2 + H_2O$$

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/dm^3) 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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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

Key

proton (atomic) number atomic symbol name relative atomic mass

Group																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

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