THE UNIFIED TRIAL EXAMINATION (2025)
KUEN CHENG HIGH SCHOOL

Senior Middle Level

CHEMISTRY
(SE11)

PAPER 2 SUBJECTIVE QUESTIONS

Date : 11 September 2025
Time : 9.30 – 11.30 am
(2 Hours)

INSTRUCTIONS TO CANDIDATES

1. This subject comprises two papers:
   Paper 1: Multiple-choice Questions (30%),
   Paper 2: Subjective Questions (70%).
2. **Paper 2** consists of two sections:
   Part I: Compulsory Questions (34%)
   Section A: Essay Questions, attempt **all** four questions.
   Section B: Inquiry Question, attempt only **one** question.
   Part II: Elective Questions (36%)
   Section A: Physical Chemistry, attempt any **one** of the two questions.
   Section B: Inorganic Chemistry, attempt any **one** of the two questions.
   Section C: Organic Chemistry, attempt any **one** of the two questions.
   You are required to attempt a total of **eight** questions.
3. Answer **each question on a fresh paper**.
4. Use only **blue** or **black** ink to write your answers, and use a pencil for drawing only.
5. Do not copy the question, but the answer to each question should be numbered clearly.
6. Essential working must be shown clearly.
7. Unless otherwise stated, chemical equations must be given wherever necessary.
8. Unless otherwise specified, the prescribed electronic calculators may be used.
9. Arrange the answer scripts in numerical order.
10. Periodic Table Sheet is on **page 2**.
11. **Paper 2** consists of eleven printed pages and one blank page.

Do Not Turn Over This Page Until You Are Told To Do So

(Candidate's Name: _____ Index Number: _____)

[CONFIDENTIAL]

Periodic Table Of Elements

IA 1	IIA 2	IIIB 3	IVB 4	VB 5	VIB 6	VIIB 7	VIIIB 8	VIIIB 9	VIIIB 10	IB 11	IIB 12	IIIA 13	IVA 14	VA 15	VIA 16	VIIA 17	VIIIA 18
1 氢 H Hydrogen 1																	2 氦 He Helium 4
3 锂 Li Lithium 7	4 铍 Be Beryllium 9											5 硼 B Boron 11	6 碳 C Carbon 12	7 氮 N Nitrogen 14	8 氧 O Oxygen 16	9 氟 F Fluorine 19	10 氖 Ne Neon 20
11 钠 Na Sodium 23	12 镁 Mg Magnesium 24											13 铝 Al Aluminum 27	14 硅 Si Silicon 28	15 磷 P Phosphorus 31	16 硫 S Sulfur 32	17 氯 Cl Chlorine 35.5	18 氩 Ar Argon 40
19 钾 K Potassium 39	20 钙 Ca Calcium 40	21 钪 Sc Scandium 45	22 钛 Ti Titanium 48	23 钒 V Vanadium 51	24 铬 Cr Chromium 52	25 锰 Mn Manganese 55	26 铁 Fe Iron 56	27 钴 Co Cobalt 59	28 镍 Ni Nickel 59	29 铜 Cu Copper 63.5	30 锌 Zn Zinc 65	31 镓 Ga Gallium 70	32 锗 Ge Germanium 73	33 砷 As Arsenic 75	34 硒 Se Selenium 79	35 溴 Br Bromine 80	36 氪 Kr Krypton 84
37 铷 Rb Rubidium 86	38 锶 Sr Strontium 88	39 钇 Y Yttrium 89	40 锆 Zr Zirconium 91	41 铌 Nb Niobium 93	42 钼 Mo Molybdenum 96	43 锝 Tc Technetium [99]	44 钌 Ru Ruthenium 101	45 铑 Rh Rhodium 103	46 钯 Pd Palladium 106	47 银 Ag Silver 108	48 镉 Cd Cadmium 112	49 铟 In Indium 115	50 锡 Sn Tin 119	51 锑 Sb Antimony 122	52 碲 Te Tellerium 128	53 碘 I Iodine 127	54 氙 Xe Xenon 131
55 铯 Cs Cesium 133	56 钡 Ba Barium 137	57-71	72 铪 Hf Hafnium 178	73 钽 Ta Tantalum 181	74 钨 W Tungsten 184	75 铼 Re Rhenium 186	76 锇 Os Osmium 190	77 铱 Ir Iridium 192	78 铂 Pt Platinum 195	79 金 Au Gold 197	80 汞 Hg Mercury 201	81 铊 Tl Thallium 204	82 铅 Pb Lead 207	83 铋 Bi Bismuth 209	84 钋 Po Polonium [209]	85 砹 At Astatine 210	86 氡 Rn Radon 222
87 钫 Fr Francium [223]	88 镭 Ra Radium 226	89-103	104 𨧀 Rf Rutherfordium [261]	105 𨨏 Db Dubnium [262]	106 𨭆 Sg Seaborgium [266]	107 𨨨 Bh Bohrium [264]	108 𨭉 Hs Hassium [269]	109 鿏 Mt Meitnerium [278]	110 鿍 Ds Darmstadtium [281]	111 𬬭 Rg Roentgenium [280]	112 鿔 Cn Copernicium [285]	113 鿭 Nh Nihonium [286]	114 鈇 Fl Flerovium [289]	115 镆 Mc Moscovium [293]	116 鉝 Lv Livermorium [293]	117 𫓧 Ts Tennessine [294]	118 氮 Og Oganesson [294]

Atomic number — 6 碳
Chemical symbol — C
Relative atomic mass — Carbon 12

镧系 Lanthanide Series	57 镧 La Lanthanum 139	58 铈 Ce Cerium 140	59 镨 Pr Praseodymium 141	60 钕 Nd Neodymium 144	61 钷 Pm Promethium [145]	62 钐 Sm Samarium 150	63 铕 Eu Europium 152	64 钆 Gd Gadolinium 157	65 铽 Tb Terbium 159	66 镝 Dy Dysprosium 163	67 钬 Ho Holmium 165	68 铒 Er Erbium 167	69 铥 Tm Thulium 169	70 镱 Yb Ytterbium 173	71 镥 Lu Lutetium 175
锕系 Actinide Series	89 锕 Ac Actinium 227	90 钍 Th Thorium 232	91 镤 Pa Protactinium 231	92 铀 U Uranium 238	93 镎 Np Neptunium 237	94 钚 Pu Plutonium [244]	95 镅 Am Americium [243]	96 锔 Cm Curium [247]	97 锫 Bk Berkelium [247]	98 锎 Cf Californium [251]	99 锿 Es Einsteinium [254]	100 镄 Fm Fermium [257]	101 钔 Md Mendelevium [258]	102 锘 No Nobelium [259]	103 铹 Lr Lawrencium [262]

Part I Compulsory Questions (34%)

Section A Essay Questions (24%)

(*Attempt **all** four questions.*)

1 Germanium, a metalloid once widely used in transistors, can be extracted from the mineral germanite, which also contains sulfur and copper.

A 1.00 g sample of germanite was heated in excess dry hydrogen chloride gas, causing all the germanium present to react and form germanium chloride. This volatile product was collected and weighed. The resulting mass of the chloride was 0.177 g. Further analysis showed that the chloride contained 33.9 % by mass of germanium.

(a) Using the data provided, determine the empirical formula of the germanium chloride prepared by the method above. **(2%)**

(b) Calculate the percentage of germanium in the original germanite sample, based on the data provided. **(2%)**

(c) Determine the oxidation number of germanium in the chloride identified in **(a)**. Justify your answer using the chemical formula and rules for oxidation numbers. **(2%)**

[Total: 6%]

2 A white solid ammonium dichromate, $(NH_4)_2Cr_2O_7$, decomposes when heated in a sealed reaction vessel to produce a mixture of gases and a solid residue. The balanced chemical equation for the decomposition is:

$$(NH_4)_2Cr_2O_7(s) \rightleftharpoons N_2(g) + 4H_2O(g) + Cr_2O_3(s)$$

This reaction is allowed to reach dynamic equilibrium at a constant temperature T in a closed system. At equilibrium, the total pressure inside the vessel is measured to be 3.0×10^3 kPa

(a) Write an expression for the equilibrium constant, K_p, for the decomposition of ammonium dichromate. Explain clearly why the solid substances are excluded from the K_p expression. **(2%)**

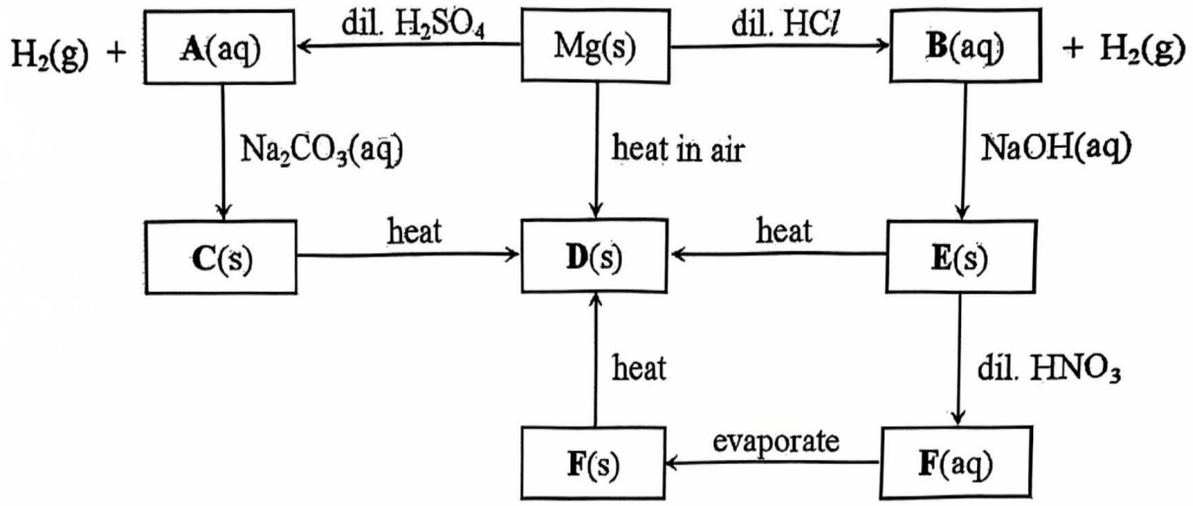
(b) Calculate the partial pressure of each gas at equilibrium. Then, calculate the value of K_p, including the correct units. **(3%)**

(c) If the temperature is increased, predict and explain qualitatively how the position of equilibrium and the value of K_p would be affected. **(1%)**

[Total: 6%]

3 Magnesium is a reactive Group 2 metal and readily forms compounds through various types of chemical reactions.

The following reaction scheme illustrates how magnesium undergoes a series of chemical transformations when it reacts with various reagents.



(a) Write a balanced chemical equation for the following reactions. **(5%)**

(i) **A**(aq) → **C**(s)

(ii) **B**(aq) → **E**(s)

(iii) **E**(s) → **F**(aq)

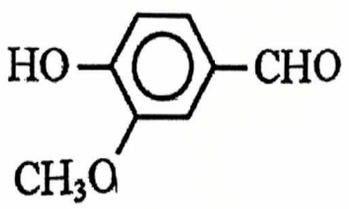
(iv) **F**(s) → **D**(s)

(v) **C**(s) → **D**(s)

(b) Explain why magnesium hydroxide (compound E) decomposes more readily upon heating compared to barium hydroxide. ( )

[Total: 6%]

4 The perfume vanillin occurs widely in nature and has the structure shown.



State the conditions and observations, and give the balanced chemical equation with structural formula when vanillin reacts with

(a) aqueous bromine **(2%)**

(b) 2,2-dimethylpropanoyl chloride **(2%)**

(c) Tollens' reagent **(2%)**

[Total: 6%]

Section B Inquiry Questions (10%)
*(Attempt the only **one** question.)*

5 This question is about calculating the purity of an impure sodium carbonate sample.

A student was given a 2.65 g impure sample of sodium carbonate (Na_2CO_3). The sample may only contain other basic impurities such as sodium hydroxide (NaOH) or sodium hydrogen carbonate ($NaHCO_3$). The student used two methods to determine the percentage purity of Na_2CO_3 in the sample.

Method 1: Titration with HCl

The entire 2.65 g sample was dissolved in 250.0 mL of distilled water.

- 25.00 mL of the prepared solution was titrated with 0.100 mol mL^{-1} hydrochloric acid using methyl orange as an indicator.
- The neutralization reaction is given as follows:

$$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$$

- The following table records the titration result obtained by the student.

Titration	1	2	3
Final burette reading (mL)	24.20	24.50	24.45
Initial burette reading (mL)	0.50	0.90	0.80
Volume of HCl used	23.70	23.60	23.65

Method 2: Thermal Decomposition

- The same 2.65 g impure sample was placed in a crucible and strongly heated to constant mass.
- The final mass of residue after heating was 2.00 g
- The thermal decomposition reaction is given as follows:

$$Na_2CO_3(s) \xrightarrow{\text{no reaction on heating}} [\text{stable}]$$

- If $NaHCO_3$ is present, it decomposes on heating:

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

(a) Based on **Method 1**, calculate the percentage purity of sodium carbonate in the sample. **(3%)**

(b) Based on **Method 2**, calculate the percentage purity of the sample, assuming the impurity is entirely $NaHCO_3$ and the residue is pure Na_2CO_3. **(1%)**

(c) Explain why both Method 1 and Method 2 are likely to overestimate the percentage purity of sodium carbonate. Justify your reasoning based on possible impurities and assumptions in each method. **(2%)**

(d) Suppose the impurity was sodium hydroxide (NaOH). Explain how it would affect the result of:

(i) Method 1 **(1%)**

(ii) Method 2 **(1%)**

(e) Suggest a chemical test that could help to distinguish between

(i) $NaHCO_3$ and Na_2CO_3. **(1%)**

(ii) NaOH and Na_2CO_3. **(1%)**

[Total: 10%]

Part I Elective Questions (36%)

Section A Organic Chemistry (12%)

*(Attempt any **one** of the two questions.)*

6 There are several structural isomers of molecular formula $C_nH_nO_2$. One of the isomers, **B**, is used as a tincture in perfumes and as a food additive.

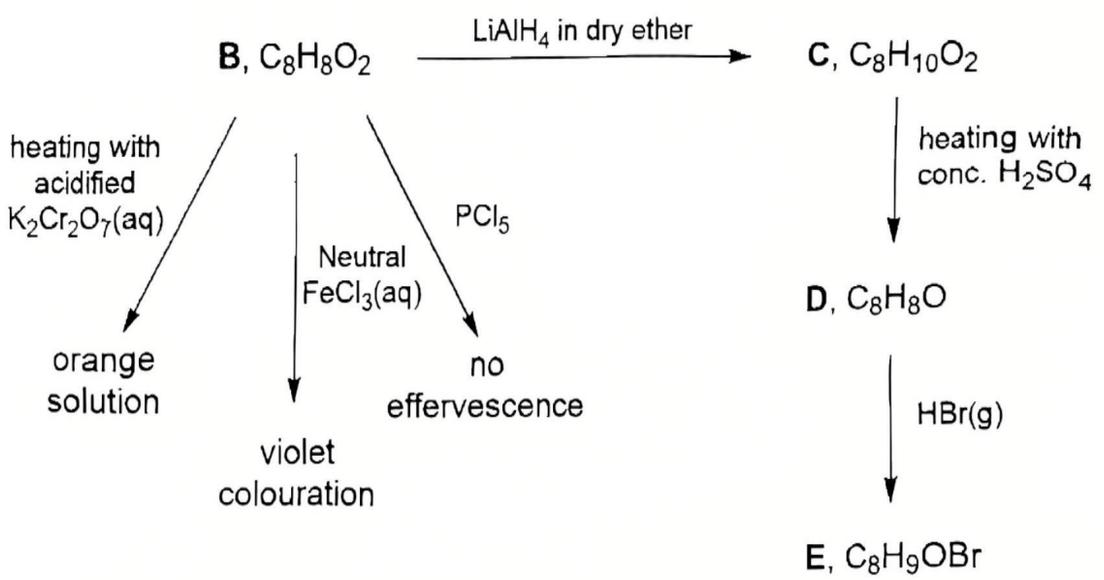
(a) To find the value of n, a 1.00 g sample of **B** was burned in an excess of oxygen, and the gases produced were first passed through a U-tube containing P_4O_{10} (to absorb the water vapour) and then bubbled through concentrated NaOH(aq). The P_4O_{10} in the U-tube increased in mass by 0.529 g.

(i) Write the combustion equation of $C_nH_nO_2$ in excess oxygen. **(1%)**

(ii) Calculate the number of moles of water produced. **(1%)**

(ii) Use the above data to calculate the value of n. **(2%)**

(b) A reaction scheme involving compound **B** and its related compounds, **C** to **E**, undergo the following reactions:



(i) Deduce the possible functional groups present in compound **B** based on the information provided above. You may refer to the following example when answering this question. **(3%)**

For example:

*Compound **A** gives an orange precipitate with 2,4-dinitrophenylhydrazine shows that it is a carbonyl compound.*

(ii) Given that, 1 mol of compound **B** reacts with excess aqueous bromine to give a white solid, compound **F** with M_r = 370. Based on the information given and your deduction on **(b)(i)**, draw the structure of compound **B** and compound **F**. **(2%)**

(iii) Draw the structures of compounds **C**, **D**, and **E**. **(3%)**

[Total:12%]

7 Compound **J** is a non-narcotic analgesic commonly sold in pharmacies. Refluxing **J** in the presence of dilute sulfuric acid produces **K** and ethanoic acid.

Tables 1 and **2** below show the results of the analysis of compound **K**.

Table 1

Elemental Analysis (%)			Melting point/ °C
C	H	O	
60.8	4.4	34.8	159

Table 2

Reaction	Reagent	Result
1	Excess aqueous Br_2	White solid, **L** formed which has Mr = 296
2	Aqueous Na_2CO_3	Effervescence of gas
3	Excess Na metal	About 174 mL of a colourless gas is evolved when 1 g of **K** is used at room temperature

(a) When vapourised in suitable apparatus, 0.12 g of K occupies a volume of 37.5 mL at 250 °C and a pressure of 101 kPa. Calculate the molar mass of K. **(1%)**

(b) Hence, using your answer in **(a)** and **Table 1**, deduce the molecular formula of **K**. **(2%)**

(c) Name the functional group that reaction **1** shows to be present in **K** and the functional group present in **K** that is confirmed by reaction **2**. **(1%)**

(d) Using your answer in **(a) – (c)** to account for the result given in reaction **3**. **(2%)**

(e) State the molecular formula of compound **L** in reaction **1**. **(1%)**

(f) Hence, suggest and draw the full structural formulae of two possible structural formulae of compound **K**. **(2%)**

(g) Given that one of the compounds in **(f)** has a melting point of 214 °C, state the identity of **K** and explain your choice. **(2%)**

(h) Hence, deduce the structure of compound **J**. **(1%)**

[Total:12%]

Section B Inorganic Chemistry (12%)
*(Attempt any **one** of the two questions.)*

8 The following question is related to halogen.

(a) The reaction between halogens and hydrogen to produce hydrogen halides is shown in the table below.

Halogen	Reaction with hydrogen
F_2	Explodes in the dark at 200 °C
Cl_2	Explodes in sunlight or slowly in the dark below 200 °C
Br_2	Occurs at 500 °C or lower temperature in the presence of a catalyst
I_2	Occurs at 450 °C in the presence of a catalyst, and the reaction is reversible.

Answer the following questions based on the table above.

(i) Explain the trend in reactivity of halogens with hydrogen as shown in the table above. In your answer, refer to the bond energy and oxidizing power of the halogens. **(3%)**

(ii) Hydrogen halides dissolve in water to form acidic solutions. Arrange the acids formed (HF, HCl, HBr, HI) in increasing order of acid strength. Explain your answer based on bond strength and ease of ionization in water. **(3%)**

(b) The reaction of halide ions with concentrated sulphuric acid can be used as a chemical test for halide ions. The result of halide ions, **X**, **Y**, and **Z**, reacting with concentrated sulphuric acid is shown in the table below.

Halide ion	Observation
X	White fumes
Y	Purple vapour
Z	Brown vapour

(i) Identify halide ion **X**, **Y** and **Z**. **(1%)**

(ii) Write the equations involved in the formation of brown vapour. **(2%)**

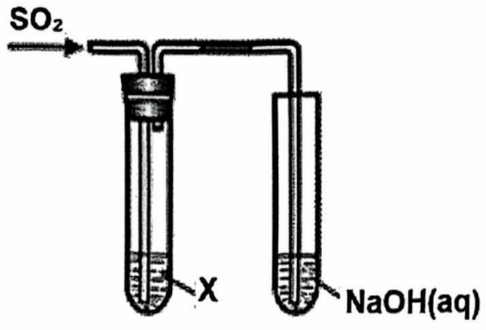
(iii) Why does **X** form only white fumes? **(1%)**

(c) Explain why chlorine gas is used in water treatment instead of fluorine gas. Refer to chemical reactivity, toxicity, and safety in your answer. **(2%)**

[Total: 12%]

9 The following question is related to sulphur dioxide.

(a) A group of students used the following apparatus to investigate the properties of SO_2.



The observations were recorded in the following table.

Experiment	X	Observation
I	Litmus solution	Observation **A**
II	Fuchsine solution	Solution changes from red to colourless; regains original colour upon heating.
III	Acidified $KMnO_4$ solution	Solution changes from purple to colourless.

Answer the following question based on the table above.

(i) In Experiment **I**, observation **A** is _____. Justify your answer with the aid of a balanced equation. **(2%)**

(ii) Based on Experiment **II**, deduce the chemical properties shown by SO_2. **(1%)**

(iii) Based on Experiment **III**, deduce the ions that are present in the colourless solution **X**

(1%)

(iv) Write a balanced equation for the reaction that happened in the test tube containing sodium hydroxide solution. **(1%)**

(b) Predict whether SO_2 will act as a reducing or an oxidizing agent in each of the following reactions. Justify your answer with balanced chemical equations.

(i) Reaction with acidified potassium dichromate (VI). **(1%)**

(ii) Reaction with hydrogen sulphide (H_2S) gas. **(1%)**

(iii) Reaction with chlorine gas (Cl_2). **(1%)**

(c) Explain why SO_2 exhibits both oxidizing and reducing behavior in terms of its oxidation state. **(1%)**

(d) Describe a chemical test to confirm the presence of sulphur dioxide gas. **(1%)**

(e) Describe a laboratory method to prepare sulphur dioxide gas. Include the chemical equation and precautions needed. **(2%)**

[Total: 12%]

Section C Physical Chemistry (12%)
*(Attempt any **one** of the two questions.)*

10 (a) In acidic solution, bromate(V) ions, BrO_3^-, slowly oxidise bromide ions to bromine. The progress of the reaction may be followed by adding a fixed amount of phenol together with some methyl red indicator.

The bromine produced during the reaction reacts very rapidly with phenol. When all the phenol is consumed, any further bromine bleaches the indicator immediately. The initial rate of formation of Br_2 is indicated by the time for the bromine to bleach the indicator.

The total volume of the reaction mixture is the same in all four experiments, and the following kinetic data are obtained at 25 °C.

Experiment	$[BrO_3^-]$ / mol dm^{-3}	$[Br^-]$ / mol dm^{-3}	pH	Initial rate of formation of Br_2 / mol dm^{-3} s^{-1}
1	0.10	0.10	1.00	8×10^{-2}
2	0.10	0.05	1.00	4×10^{-2}
3	0.05	0.05	1.00	2×10^{-2}
4	0.05	0.10	1.30	1×10^{-2}

(i) Write a balanced equation for the reaction between bromide ion, Br^-, and bromate(V) ion, BrO_3^-. **(1%)**

(ii) Write the rate equation for this reaction and determine the order of the reaction concerning reactants, Br^-, BrO_3^- and H^+. **(3%)**

(iii) Calculate the rate constant of the reaction at this temperature, stating its units. **(1%)**

(b) Describe and explain in molecular terms how the rate of reaction is affected by an increase in temperature. You should include a reference to the Boltzmann distribution in your answer. **(3%)**

(c) The effect of temperature on the rate constant, k, can be expressed by the following equation.

$$\ln k = \ln A - \frac{E_a}{R}\left(\frac{1}{T}\right)$$

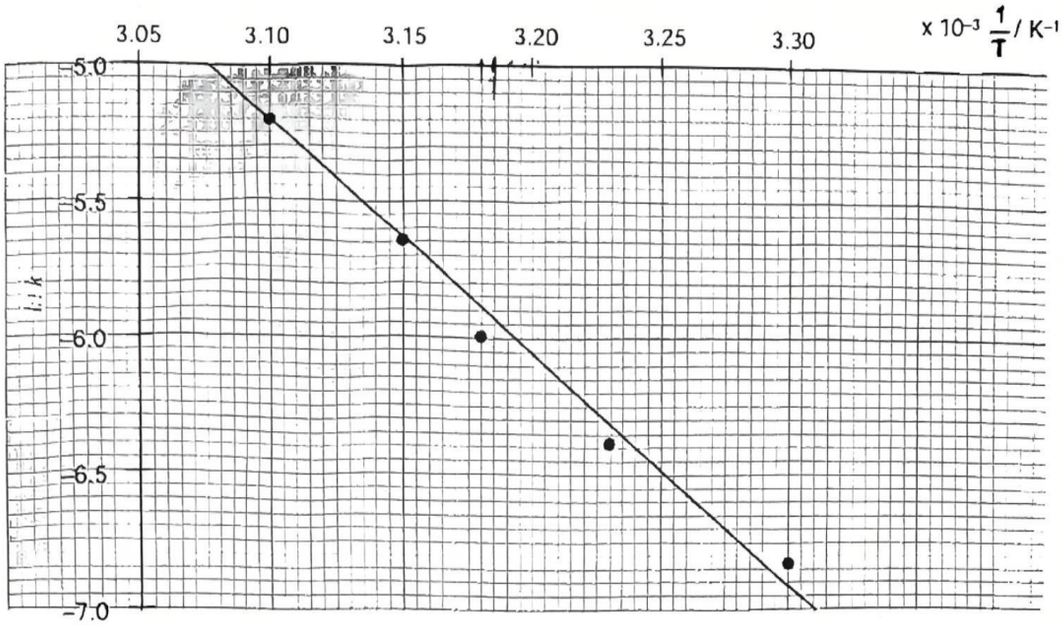
A is constant.

E_a is the activation energy.

R is the molar gas constant (8.314 J K^{-1} mol^{-1}).
T is the absolute temperature.

In a separate experiment to investigate the effect of temperature on the rate constant of the reaction between bromide ion and bromate(V) ion, the graph below was obtained.

Graph of ln *k* versus $\frac{1}{T}$



(i) Calculate the activation energy, E_a, of the reaction. **(1%)**

(ii) Suggest why the activation energy of the reaction is high. **(1%)**

(iii) Sketch the graph shown above onto your writing paper. On the same axes, sketch the graph of ln *k* versus $\frac{1}{T}$ when the reaction proceeds in the presence of a catalyst. Label your graph clearly and explain your answer. **(2%)**

[Total: 12%]

11 Vitamin C is an essential nutrient also known as ascorbic acid. A deficiency of vitamin C leads to a disease known as scurvy.

(a) Ascorbic acid is a monobasic acid, H**A**, with the acid dissociation constant of 7.943×10^{-5}. The amount of ascorbic acid contained in dietary supplement tablets can be verified by titration. A tablet containing 500 mg of ascorbic acid was dissolved in 25.0 mL of deionised water.

(i) Calculate the volume of 0.100 M sodium hydroxide required for complete neutralisation. **(1%)**

(ii) Calculate the initial pH of the ascorbic acid solution. **(2%)**

(iii) Suggest a suitable indicator for the titration. Describe the expected colour change at the endpoint. **(1%)**

(iv) With the aid of a suitable equation, explain your choice of indicator in **(iii)**. **(3%)**

(c) When a vitamin C tablet is swallowed, it dissolves in the stomach. The pH of the stomach is 2.

(i) Determine the percentage of ascorbic acid that is ionised in the stomach. **(2%)**

The pH of blood is maintained at 7.35 by a H_2CO_3/ HCO_3^- buffer.

(ii) Define what is meant by buffer solution. **(1%)**

(iii) Using appropriate equations, explain how the buffer minimises changes in pH. **(2%)**

[Total: 12%]

– END OF QUESTIONS –

Prepared by: Chong Yee Ting