M20/4/CHEM/ENG/TZX/XX

NN Classroom Mock Exam

Chemistry

Higher level

Paper 2

Candidate session number

2 hours

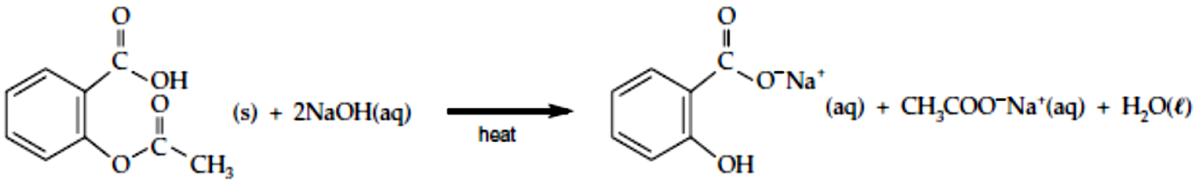
Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[80 marks]**.

Where there is a will, there is a way.

Answer **all** questions. Answers must be written within the answer boxes provided.

1. The percentage by mass of active ingredient of aspirin (acetyl-salicylic acid) in an aspirin tablet was determined by adding excess sodium hydroxide to ensure that all acetyl-salicylic acid had reacted according to the following reaction.



The excess alkali left was then titrated with aqueous hydrochloric acid.

(a) A student added 25.00 cm^3 of 1.0 mol dm^{-3} sodium hydroxide (in excess) to 2.00 g of tablet. Calculate the amount, in mol, of sodium hydroxide added initially.

[1]

(b) The excess alkali was diluted to 250.0 cm^3 with distilled water. From that volumetric flask, 25.00 cm^3 was extracted and titrated with 0.050 mol dm^{-3} hydrochloric acid using phenolphthalein as the indicator. The excess sodium hydroxide requires 16.50 cm^3 of the acid to meet the end point. Calculate the amount, in mol, of alkali that is in excess from the original sodium hydroxide solution in part (a).

[3]

(c) State the expected colour change at the end point.

[1]

(d) Determine the amount, in mol, of sodium hydroxide that reacted with the acetyl-salicylic acid in the tablet.

[1]

(e) Calculate the mass and percentage by mass of acetyl-salicylic acid in the sample of aspirin tablet.
(Molar mass of acetyl-salicylic acid = 180.0 g mol^{-1})

[3]

(f) Deduce one assumption made for this experiment in arriving at the percentage by mass of acetyl-salicylic acid in the tablet sample.

[1]

2. Ethane, C_2H_6, is an organic compound belongs to a homologous series called alkane.

(a) State three features when organic compounds belong to the same homologous series.

[3]

(b) Ethane can be converted into ethanol in two steps. Show the conversion pathway by listing the reagents, conditions and intermediate compound.

[3]

(c) Explain the reaction mechanism in step 2, using curly arrows to indicate the movement of electron pairs.

[4]

(d) Suggest why polar, aprotic solvents are more suitable for S_N2 reactions whereas polar, protic solvents favour S_N1 reactions.

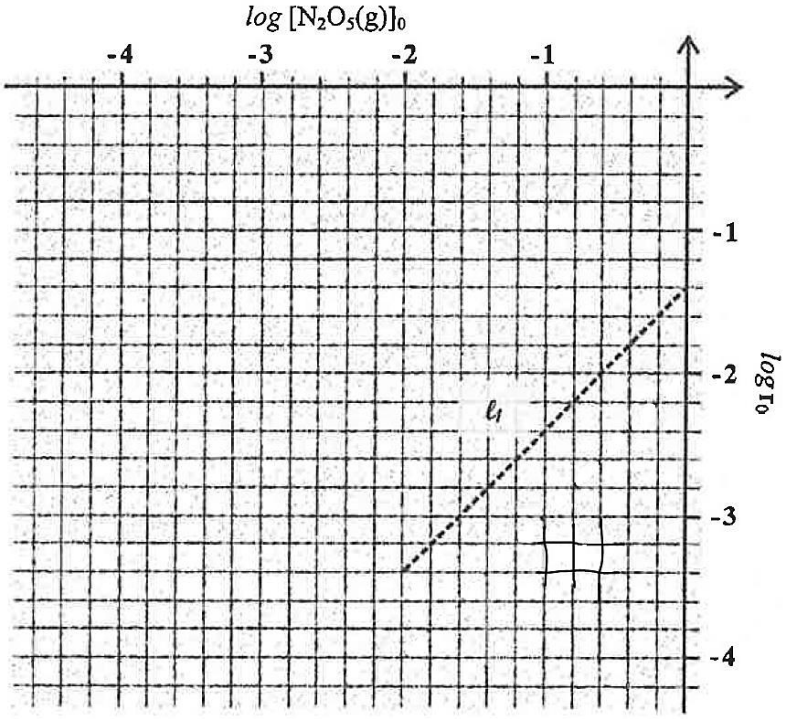
[2]

3. An experiment was performed to study the rate order and rate equation of the decomposition of N_2O_5 (g).

$2\ N_2O_5\ (g) \rightarrow 4\ NO_2\ (g) + O_2\ (g)$

From the experiment, various concentrations of N_2O_5 (g) were used to investigate the initial rate of the decomposition under constant temperature. The variation of log r_0 with log $[N_2O_5\ (g)]_0$ was plotted and a straight line was obtained as shown below.

	Meaning	Unit
$[N_2O_5\ (g)]_0$	Initial concentration of N_2O_5 (g)	mol dm^{-3}
r_0	Initial rate of decomposition of N_2O_5 (g)	mol dm^{-3} s^{-1}



(a) Calculate the slope and deduce its chemical meaning.

[2]

(b) Deduce the y-intercept and its chemical meaning.

[2]

(c) Hence, calculate the rate constant and state the rate equation under the specified constant temperature.

[2]

(d) Additional experiments were carried out at an elevated temperature. On the space below, sketch Maxwell–Boltzmann energy distribution curves at two temperatures T_1 and T_2, where $T_2 > T_1$.

[2]

4. Consider the following reversible reaction between 3 gases, **X**, **Y**, and **Z**.

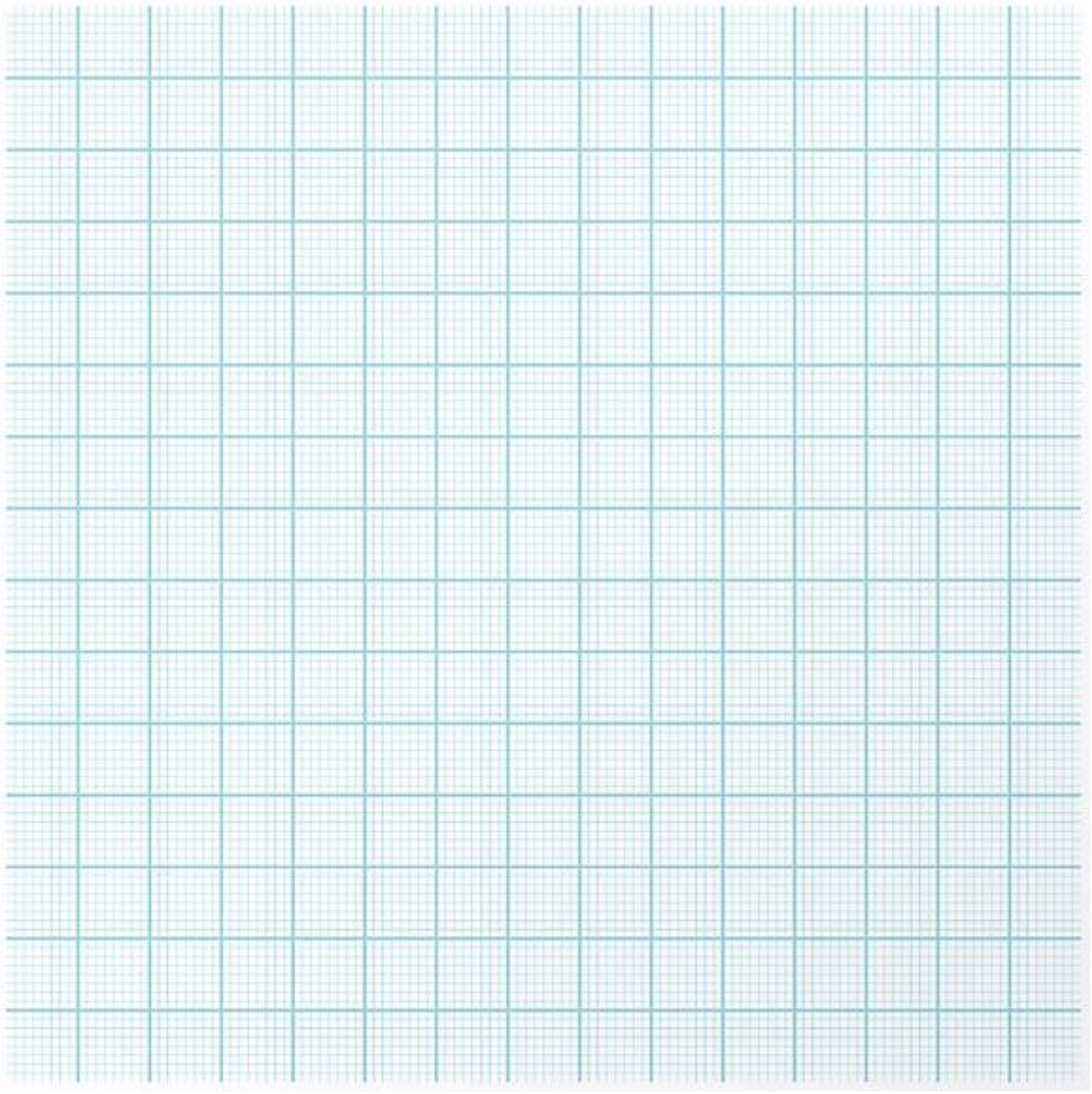
X (g) + **Y** (g) ⇌ **Z** (g)

An experiment was conducted in tracing the change in concentrations of **X**, **Y** and **Z** with time. Reactants were allowed to react inside a 2.0 dm^3 closed vessel. Results were shown in the following table.

Time / minute		0	10	20	30	40	50	Data missing	110	120	130
Concentration ($mol\ dm^{-3}$)	**X**	0.34	0.24	0.21	0.20	0.20	0.20		0.40	0.40	0.40
	Y	0.59	0.49	0.46	0.45	0.45	0.45		0.50	0.50	0.50
	Z	0	0.11	0.14	0.15	0.15	0.15		0.10	0.10	0.10

(a) Plot a corresponding graph showing the changes in concentrations of the 3 gases within the two time intervals.

[3]



(b) At 50 min., 0.3 moles of **X** were added to the system without changing the temperature. A new equilibrium was established at 70 min. This new equilibrium state held from 70 min. to 90 min.

(i) What are the concentrations of all gases at the new equilibrium state ?

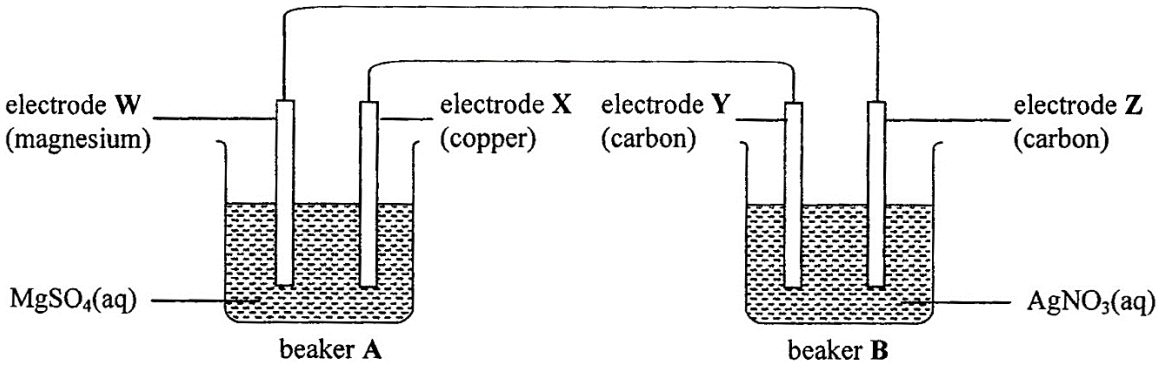
(ii) Complete the graph from 50 min. to 90 min.

[5]

(c) At 90 min., the temperature of the system is increased. A new equilibrium state is established at 110 min. Complete the graph from 90 min. to 110 min. Hence, calculate the new equilibrium constant with the corresponding unit.

[2]

5. The diagram below shows a set-up in which electrons are flowing through the electric wires. Moreover, one of the electrodes in beaker **A** is forming ions.



(a) Explain the role played by beaker **A** and beaker **B** when the circuit is closed.

[4]

(b) Formulate the half-equations for the reaction in each of the electrodes.

[4]

(c) If the circuit running through the setup use a current of 0.50 A for 30 minutes. What is the mass of product that can be obtained at electrode **Z** ?

[3]

6. Incomplete combustion of fossil fuels can generate toxic gases. Carbon monoxide is one of them.

(a) Draw the Lewis (electron dot) structure of carbon monoxide.

[1]

Apart from carbon monoxide, sulphur dioxide is another common air pollutant generated when burning coals that contain sulphur impurities. It will lead to the issue of acid rain.

(b) State the hybridization of the sulphur atom in sulphur dioxide.

[1]

(c) Deduce the molecular and electron domain geometry of sulphur dioxide and estimate its O-S-O bond angle.

[3]

(d) Formulate the chemical equation when sulphur dioxide is dissolved in rainwater.

[1]

(e) Suggest a solution in tackling with acid rain.

[1]

(f) Explain the fact that sulphur dioxide exists as a gas whereas silicon dioxide exists as a solid.

[3]

7. Sodium chloride is an ionic compound also known as table salt. It is highly soluble in water, causing an endothermic reaction to occur.

(a) Define the term “hydration enthalpy” and “average bond enthalpy”

[2]

(b) Using the information shown below, construct a Born-Haber cycle and hence calculate the lattice enthalpy of sodium chloride.

[4]

	Enthalpy / kJ mol^{-1}
$\Delta H^{\circ}_{formation}$(sodium chloride)	–411
$\Delta H^{\circ}_{atomization}$(sodium)	+109
$\Delta H^{\circ}_{atomization}$(chlorine)	+121
1st ionization energy (sodium)	+494
1st electron affinity (chlorine)	–364

(c) Given that the enthalpy change of solution of NaCl is +7 kJ mol^{-1}. Calculate the total hydration enthalpies of sodium and chloride ions. Show your working by constructing a Hess’s cycle.

[3]

8. Vinegar contains ethanoic acid, which is a weak acid with a pK_a of 4.76 under room temperature.

(a) Outline why ethanoic acid is classified as a weak acid.

[1]

(b) Deduce the base dissociation constant (K_b) of the conjugated base of ethanoic acid under room temperature. Use section 23 of the data booklet.

[2]

(c) Explain, using **two** equations, how an equimolar solution of ethanoic acid and ethanoate ions acts as a buffer solution when small amounts of acid or base are added.

[2]

(d) Hence, deduce the pH of the above buffer solution.

[2]

(e) Predict and explain any difference in the C-O bond lengths from ethanoic acid and ethanoate ion.

[3]