

Candidate's Name:.....

Signature.....

Random No.

Personal No.

BOARD OF REGIONAL MOCKS ASSOCIATION
Uganda Advanced Certificate of Education
(BRMA)



CHEMISTRY
525/1
THEORY
2 ½ HOURS

INSTRUCTIONS TO CANDIDATES

- This paper consists of two sections A and B. Section A consists two compulsory items.
Write your responses to items in section A in the spaces provided
Section B consists of two parts I and II; attempt only one item from each part.
- Write your responses to Section B on the answer sheets provided. Begin response to each item on a fresh page.
Respond to four items in total.
- A Periodic Table is provided, refer to it whenever required.

BOARD OF REGIONAL MOCKS ASSOCIATION
0765588155

Item 2

A pharmaceutical formulation company in Gulu is in the middle of a product-development crisis. They are scaling up production of a new oral suspension drug that uses ethoxyethane as the extraction and purification solvent. During pilot trials, the solvent recovery step has become unreliable: boiling points of the process solutions are consistently higher than expected, leading to incomplete distillation, excessive energy consumption, product degradation, and costly production delays.

To diagnose the problem, the quality-control laboratory prepared solutions of benzoic acid (a non-volatile solute) in a fixed 150 g of ethoxyethane and measured the boiling points of each at exactly 1 atmosphere pressure.

Below is the data from their trial runs:

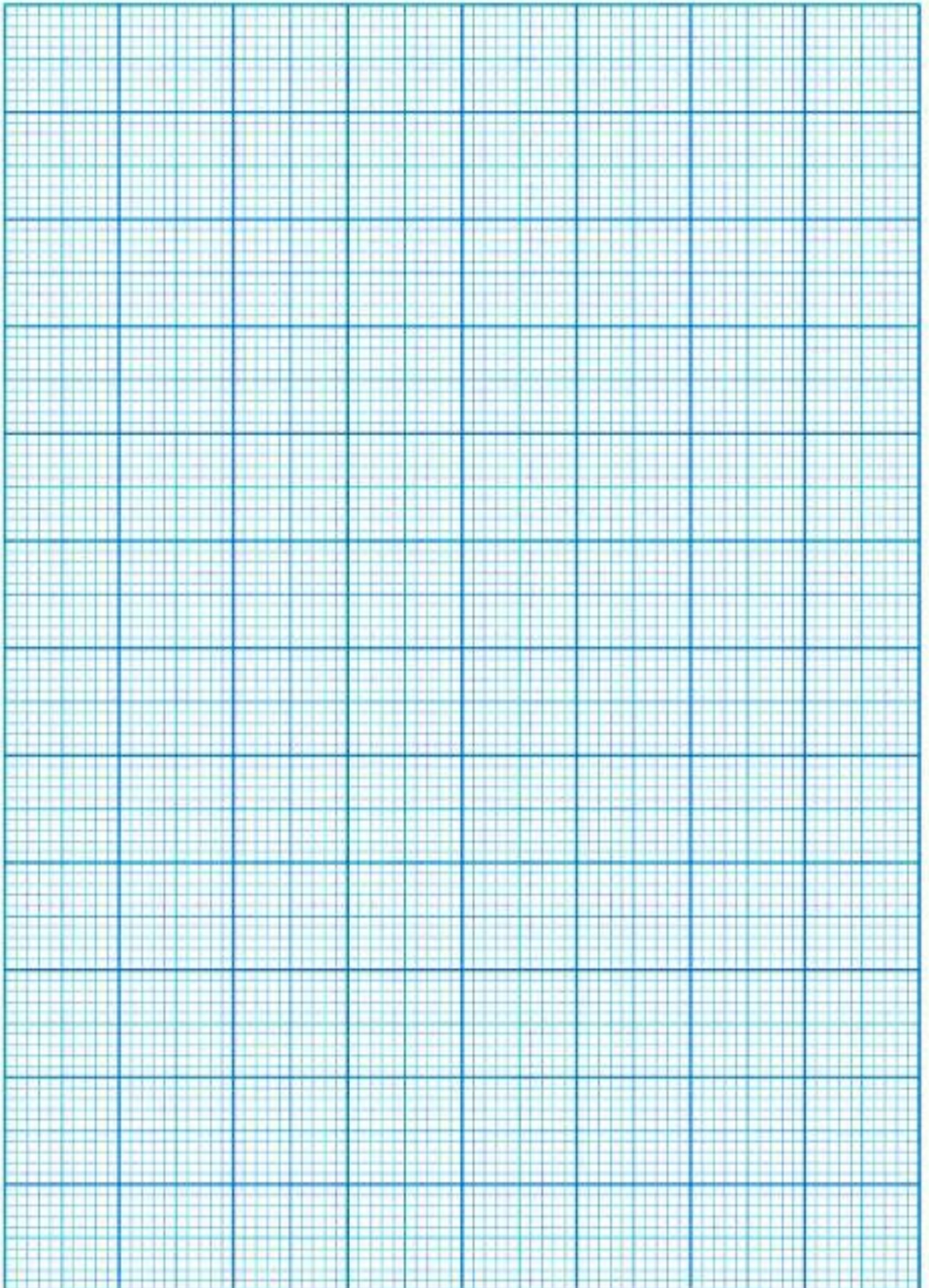
Table 2

Mass of benzoic acid, m (g)	5	10	15	20	25
Boiling temperature, t (°C)	35.09	35.68	36.27	36.86	37.45

Task

The production manager of the company has invited help from your A-Level Chemistry class that is on a study tour to the company to review the laboratory findings and help with:

- A clear explanation of how a non-volatile solute affects the boiling point of a volatile solvent at constant external pressure. They also need the laboratory data to be analysed so that the ebullioscopic constant of ethoxyethane can be determined.



SECTION B PART I

(Attempt any one item in this section)

Item 3

A chemical manufacturing company is exploring new product lines to expand its portfolio. They are particularly interested in scaling up production of 2-methylpropan-2-ol for use as a high-octane fuel additive and industrial solvent. The company has received a new organic liquid Z from a potential supplier, together with combustion analysis data: Combustion of 0.60 g of Z produced 1.32 g of CO₂ and 0.72 g of H₂O. The molecular mass of Z determined by mass spectrometry is 80. The quality control laboratory has also isolated three compounds with different boiling points from a sample of Z and labelled them U, V and W. Table 3 has data on these compounds:

Table 3

Compound	Boiling point (°C)
U	97
V	82
W	7

Management needs to understand the nature of Z, understand why Z is made of a mixture of different compounds and which of these is most suitable as a starting material for the synthesis of 2-methylpropan-2-ol (via propanone), and evaluate a viable synthesis route before committing to large-scale procurement and process development. The production manager has invited the help of the Chemistry department in your school to review the laboratory data and submit expert recommendations ahead of the next product-line planning meeting.

Task

As a student of Chemistry on the head of department's help prepare a technical report for the production and quality-control team.

Item 4

The National Environment Management Authority (NEMA) is reviewing an application from a plastics recycling and manufacturing firm in Mukono District that plans to establish a new production line for polypropylene. The company has received two unsaturated aliphatic C_3 hydrocarbon feedstocks from industrial by-products, of molecular masses, 42 and 40, but the identical-looking containers were accidentally mixed up during storage. The firm also has a supply of 2-chloropropane, which they intend to convert into one of the hydrocarbons above via an elimination reaction before using it in the polymerisation step. NEMA is particularly concerned about the environmental impact of the final plastic product, the feasibility and safety of the proposed synthetic routes (including the detailed step-by-step reaction pathway when converting 2-chloropropane to the required alkene), and whether the chosen pathway represents the most sustainable option before granting regulatory approval. The Director of Environmental Compliance has sought for your help as head of Chemistry class in your school to analyse the situation and prepare expert advice ahead of the regulatory approval meeting.

Task

Prepare a technical report for the NEMA review panel.

PART II

(Attempt any one item in this section)

Item 5

A group of university interns from the Department of Foods and Nutrition at Makerere University are on attachment with a local nutritional supplement company in Kampala. They have been asked to develop a new, low-cost, self-heating food warmer sachet that can be added to school feeding programmes and maternal nutrition packs in rural areas where electricity and fuel are unreliable. The warmer works by the exothermic reaction of one of the metals listed in the data table below with water to generate enough heat to warm the food quickly and safely.

The interns have been given the following data:

Table 5

Element	Atomic number	Atomic radius (pm)	First ionisation energy (kJ mol ⁻¹)
Beryllium	4	112	900
Magnesium	12	160	738
Calcium	20	197	590
Strontium	38	215	550
Barium	56	222	503

They have also observed that these metals show very different rates of reaction with cold water and that beryllium behaves differently from the rest of the metals in several ways. Before finalising the formulation, the company needs a clear scientific evaluation of these elements — including their classification in the periodic table, the reasons for the observed trends in reactivity (using the provided atomic radii and ionisation energies), a description of how each metal reacts with water to illustrate the reactivity trend, and an explanation of beryllium's anomalous behaviour — to decide which metal is most suitable for the self-heating food warmer.

The head of the internship programme has asked you to review the data and prepare expert advice for the interns ahead of their presentation to the company's product development team next week.

Task

As a student of Chemistry prepare a concise technical report for the product development team.

Item 6

A materials development company based in Namanve Industrial Park is working on a new high-performance ceramic coating for solar panels and modern construction materials. The coating must withstand very high processing temperatures, resist long-term exposure to moisture, and remain stable in mildly alkaline conditions (such as those found in cement-based building products). The research team is considering five group 14 elements — carbon, silicon, germanium, tin and lead — as the base material for the coating.

The team has been given the following group trend data:

Table 6

Element	Atomic radius (pm)	Electronegativity (Pauling Scale)	Melting point (°C)
Carbon	77	2.55	3652 (sublimes)
Silicon	118	1.90	1414
Germanium	122	2.01	938
Tin	140	1.96	232
Lead	146	2.33	328

They have also noted that the elements show different behaviours when exposed to water and alkalis, and that their oxides differ markedly in the relative stability of the +2 and +4 oxidation states down the group.

Before committing to large-scale pilot production, the company needs a clear scientific evaluation and understanding of these elements' properties to decide which one (or whose oxide) will give the best combination of high-temperature stability, resistance to water and alkalis, and long-term durability in the final coating.

The head of research has invited your A-Level Chemistry class to help review and interpret the data and prepare expert recommendations ahead of the critical product-selection meeting soon to take place.

Task

Prepare a brief but concise technical report for the research and product development team.

END