

**P525/1**  
**CHEMISTRY**  
Paper 1  
April / May 2026  
2¼ Hours

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**HAPPY MOTHER'S DAY — 10 MAY 2026**

*"This paper is dedicated with love and gratitude to every mother — whose sacrifices, strength, tireless care and unconditional love shape the scientists, doctors and engineers of tomorrow."*



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**JOEL PCM ACADEMIC COUNCIL**  
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**CHEMISTRY THEORY**  
**Paper 1**

**INSTRUCTIONS TO CANDIDATES**

This paper consists of two sections: Section A and Section B.

Section A has two compulsory items.

Section B has two parts — Part I and Part II — each with two items; answer only one item from each part.

Respond to four items in all.

For each item, read the scenario carefully, identify the chemical problems presented, and write a comprehensive scientific report addressing all issues.

All working must be clearly shown where calculations are required.

Molar volume of gas at s.t.p = 22.4 dm<sup>3</sup> mol<sup>-1</sup>. R = 8.314 J K<sup>-1</sup> mol<sup>-1</sup>. L = 6.02 × 10<sup>23</sup> mol<sup>-1</sup>.

Standard temperature = 273 K. Standard pressure = 101 325 Nm<sup>-2</sup>.

**FOR EXAMINERS' USE ONLY**

Item	1		2						3/4		5/6			Tot al					
Code	F <sub>1</sub>	C <sub>2</sub>	D <sub>1</sub>	C <sub>3</sub>	D <sub>2</sub>	Ec	C <sub>4</sub>	C <sub>5</sub>	E <sub>1</sub>	P	D <sub>3</sub>	Gr	Tr	Pr	D <sub>4</sub>	Se	Mc	D <sub>4</sub>	

<b>Score</b>																		
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**PTO**

## SECTION A

*Respond to ALL items in this section.*

### ITEM ONE

#### A MOTHER'S REMEDY

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In a small trading centre in Kabale district, a 47-year-old mother of six, Mrs Birungi, has been experiencing persistent stomach ulcers, acid reflux, and joint pains attributed to calcium deficiency. Her local pharmacist, who is also a chemistry teacher at a nearby secondary school, decides to formulate a low-cost antacid and calcium supplement using calcium hydroxide —  $\text{Ca}(\text{OH})_2$  — sourced from a construction materials supplier.

The pharmacist prepares a batch of the medicine by dissolving calcium hydroxide in water, but immediately encounters a problem: the mixture appears cloudy and milky rather than forming a clear solution, and a white solid settles at the bottom of the bottle after a few minutes. Despite shaking, the solid refuses to dissolve completely. The pharmacist recalls from his chemistry knowledge that calcium hydroxide is sparingly soluble, and that its solubility product  $K_{\text{sp}}$  at  $25^\circ\text{C}$  is  $5.5 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9}$ .

Concerned about inconsistent dosing, the pharmacist measures the pH of the saturated solution using a calibrated pH meter and records a value of 11.7. He then attempts to increase the solubility of  $\text{Ca}(\text{OH})_2$  by adding a small amount of ammonium chloride solution to the mixture, hoping the acidic environment will drive more  $\text{Ca}(\text{OH})_2$  into solution. The graph below shows how the solubility of  $\text{Ca}(\text{OH})_2$  changes with temperature:

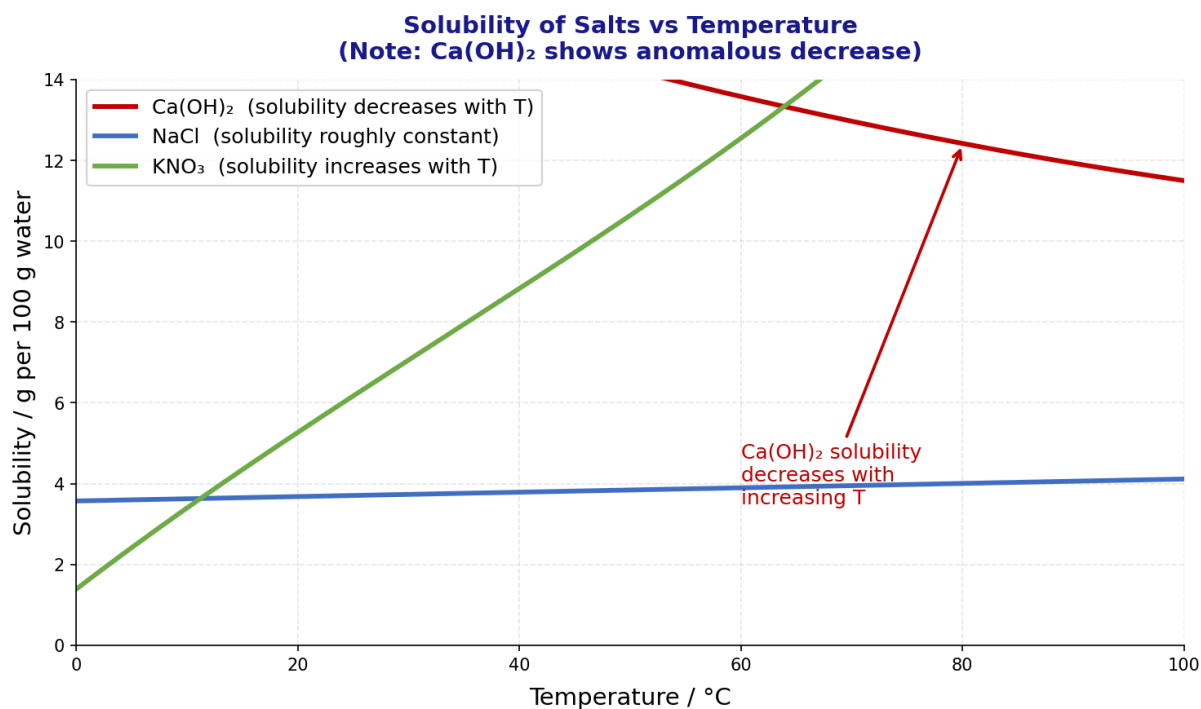


Fig. 1: Solubility of  $\text{Ca(OH)}_2$ ,  $\text{NaCl}$  and  $\text{KNO}_3$  as a function of temperature

During the same week, Mrs Birungi's teenage daughter, a Senior 5 chemistry student, visits the pharmacy and studies the pH scale chart displayed on the wall. She notices that the pharmacist's  $\text{Ca(OH)}_2$  solution is far more alkaline than the normal physiological pH range of the human stomach (pH 1.5–3.5) and the blood (pH 7.35–7.45). She wonders how the body maintains such precise pH values despite the constant production of acids and bases, and asks her father about the role of buffer systems in the body.

The pharmacist also explains that the medicine will be packaged in 200 cm<sup>3</sup> bottles. Each dose is 5.0 cm<sup>3</sup> of the saturated  $\text{Ca(OH)}_2$  solution. He wants to know exactly how many moles of  $\text{Ca(OH)}_2$  are delivered per dose, and how many doses are in one bottle. He further considers adding 2.0 g of glucose ( $\text{C}_6\text{H}_{12}\text{O}_6$ ) to each bottle as a sweetener and wants to verify that this does not significantly affect the freezing point of the solution, since the medicine must be stored in a cool box at  $-2^\circ\text{C}$  during hot weather.

### The pH Scale with Common Household and Medicinal Substances

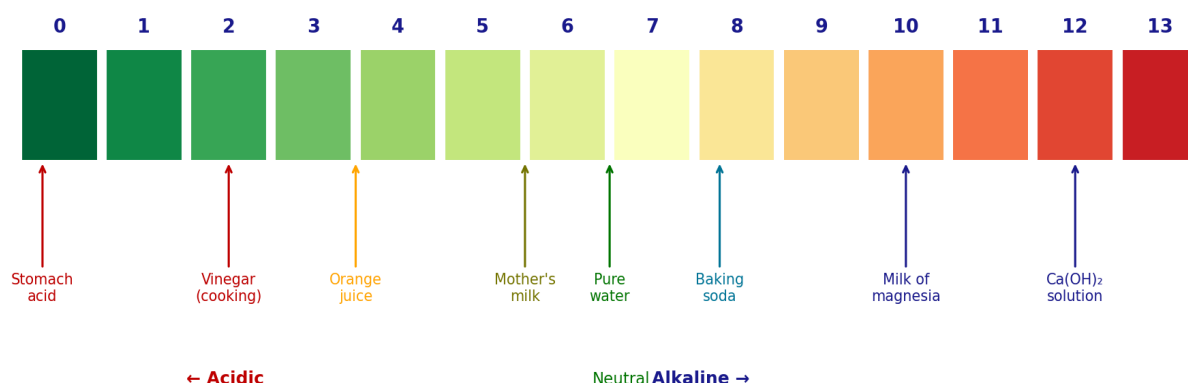


Fig. 2: pH scale showing common household and medicinal substances

Before the medicine can be approved for community use, the district health inspector requires a full written scientific report explaining the chemistry behind all the observations and calculations involved in this formulation process. The inspector notes that the pharmacist must also address any safety concerns arising from the highly alkaline nature of the solution and suggest how the pH can be adjusted to a safer range for oral administration.

#### Task;

As a chemistry learner, analyse the scenario above and write a comprehensive scientific report for the district health inspector addressing all the chemical issues, observations and calculations identified in the situation.

## ITEM TWO

### COOKING FOR MOTHER

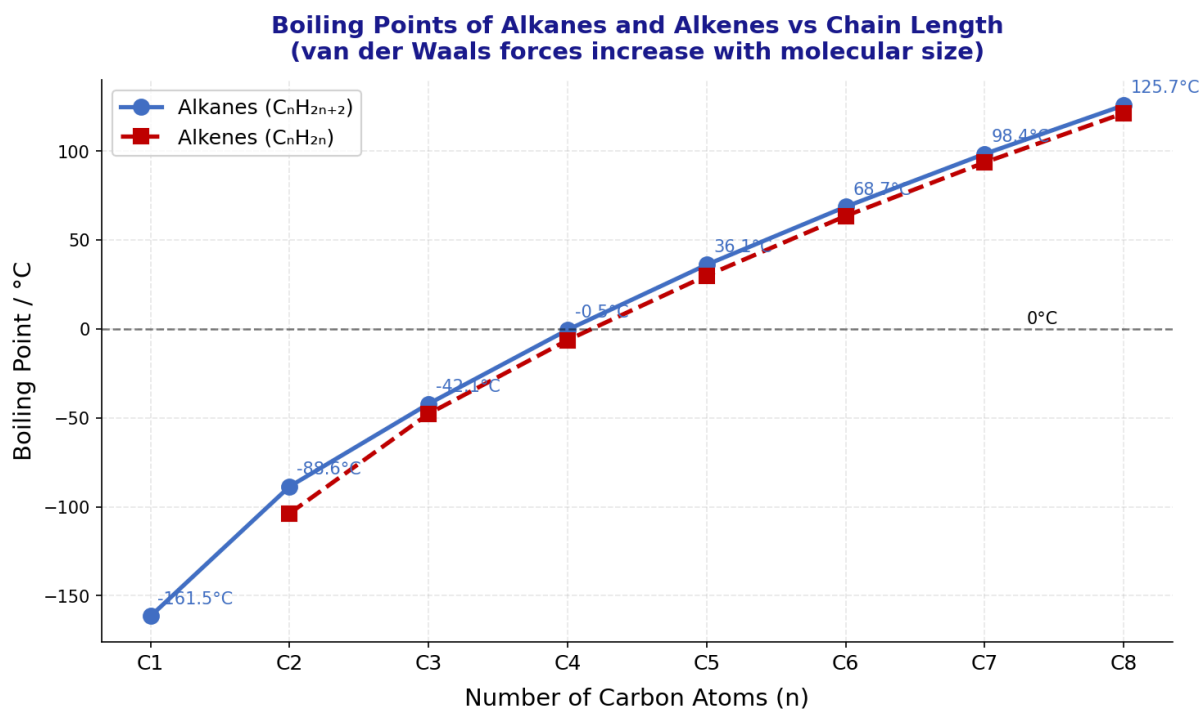
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On the morning of Mother's Day, the Nakamya family in a village outside Masaka town decides to prepare a special meal for their mother, who has dedicated 25 years to farming and raising five children. The eldest son, David, who is studying chemistry at Uganda Christian University, takes charge of the cooking. The family uses three different fuel sources in their homestead: firewood, kerosene (a mixture of hydrocarbons with 10–16 carbon atoms), and a small biogas plant that produces methane ( $\text{CH}_4$ ) from cow dung.

David notices several interesting things as he cooks. When he lights the kerosene stove, it produces a bright yellow, sooty flame and leaves black carbon deposits on the bottom of the cooking pot. The biogas burner, however, burns with a clean, almost invisible blue flame and produces no soot. He recalls from his chemistry lectures that the nature of combustion depends on the carbon-to-hydrogen ratio of the fuel and the amount of oxygen available.

To demonstrate the chemistry to his younger siblings, David collects a  $1.12 \text{ dm}^3$  gas sample of biogas (pure methane) at standard temperature and pressure and burns it completely in a controlled experiment. He measures the volume of  $\text{CO}_2$  produced and the mass of water formed. In another experiment, David takes a sample of an unknown pure liquid hydrocarbon Q extracted from the kerosene, and completely combusts 0.86 g of it in excess oxygen. The products are 2.64 g of  $\text{CO}_2$  and 1.08 g of  $\text{H}_2\text{O}$ .

David's sister, Sarah, who is in Senior 5, is studying the homologous series. She is puzzled by why kerosene ( $\text{C}_{10}$ – $\text{C}_{16}$  hydrocarbons) is a liquid at room temperature while methane ( $\text{CH}_4$ ) and propane ( $\text{C}_3\text{H}_8$ ) are gases, even though they all belong to the same alkane family. She refers to the boiling point data chart below:



*Fig. 3: Boiling points of alkanes and alkenes vs number of carbon atoms*

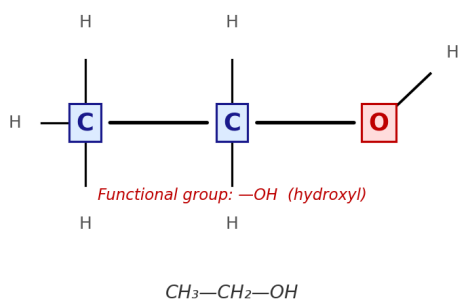
Later, David conducts a simple test: he adds a few drops of kerosene and a few drops of a different unknown hydrocarbon R (obtained separately) to separate test tubes containing bromine water. The kerosene causes no colour change in the bromine water, but hydrocarbon R immediately decolourises the bromine water at room temperature without UV light. He also notices that when he adds acidified potassium manganate(VII) solution to R, the purple colour is discharged.

While cleaning up, David accidentally spills a small amount of ethanoic acid (vinegar, CH<sub>3</sub>COOH) used in the salad dressing. He neutralises it with baking soda (sodium hydrogencarbonate, NaHCO<sub>3</sub>). He observes vigorous effervescence and wonders about the mole relationships in the reaction.

The structural formulae of ethanol and ethanoic acid — both organic compounds present in the kitchen — are shown in Fig. 4 for reference:

## Organic Compounds Found in Household and Food Products

### Ethanol (C<sub>2</sub>H<sub>5</sub>OH)



### Ethanoic acid (CH<sub>3</sub>COOH)

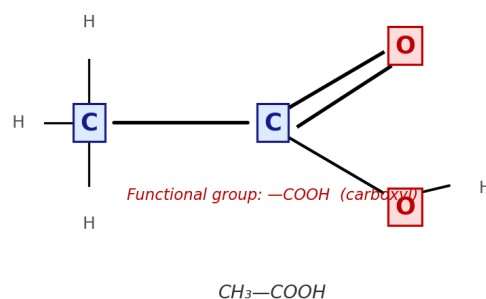


Fig. 4: Structural formulae of ethanol and ethanoic acid

The family chemistry teacher, who is visiting for Mother's Day lunch, overhears the discussions and suggests that David write up all his observations and calculations as a structured chemistry report to present to his class on Monday.

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### Task;

As a chemistry learner, analyse the scenario above and write a comprehensive scientific report addressing all the chemical problems, observations and calculations identified in the situation.

## SECTION B

### Part I

*Respond to only ONE item from this part.*

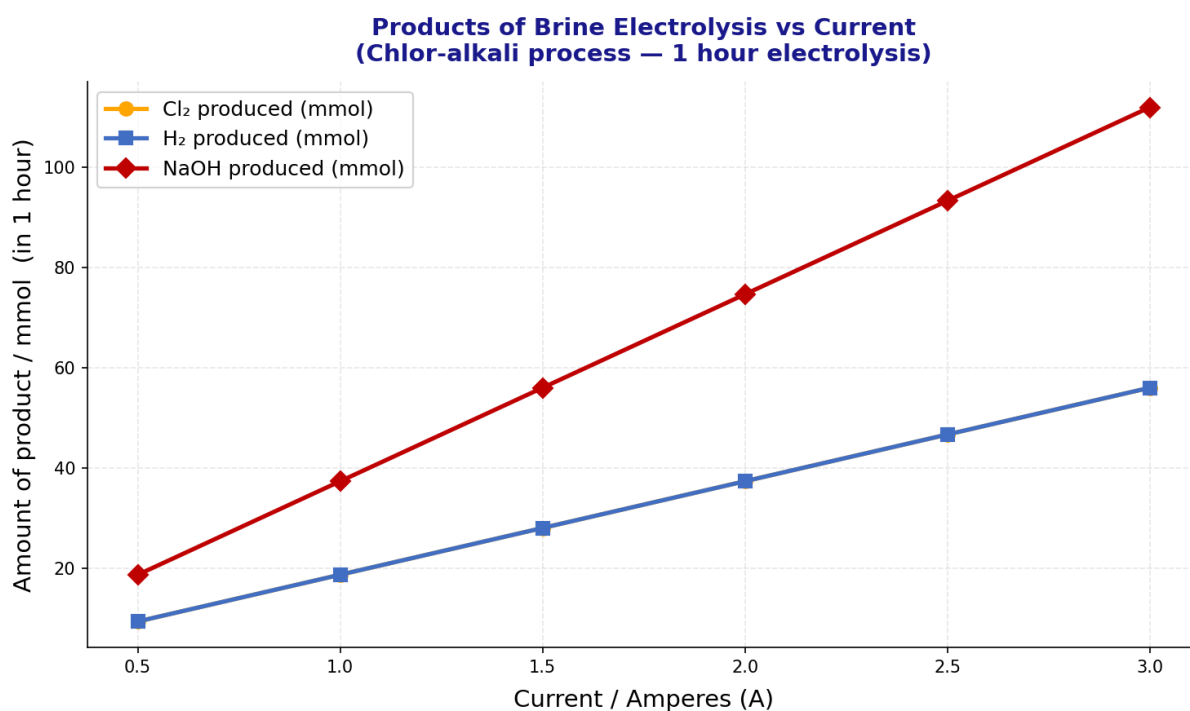
#### ITEM THREE

##### MOTHER'S GOLDEN BUSINESS

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Mrs Nalwoga is a determined single mother of three in Kampala who runs a small jewellery electroplating business from home to pay school fees for her children. She plates cheap metal trinkets with gold, silver and copper using electrolytic cells. One morning she notices that her copper plating bath — a solution of copper(II) sulphate — is producing uneven, dull deposits on the jewellery pieces, and some pieces are showing dark brown powdery deposits rather than the expected smooth, shiny copper coating.

A neighbour who studied chemistry offers to investigate. He notices that the current Mrs Nalwoga is using (3.0 A) is too high for small pieces, the copper(II) sulphate concentration has dropped significantly because the anode is impure and not dissolving at the expected rate, and the electrodes are too far apart, increasing resistance. He also notices that the same brine solution used to clean the jewellery before plating — 200 cm<sup>3</sup> of 2.0 mol dm<sup>-3</sup> NaCl — has been accidentally left connected to a second electrolytic cell for 2 hours at 0.5 A, and is now producing gases at both electrodes. The products of this unintended electrolysis are shown in the graph below:



*Fig. 5: Moles of Cl<sub>2</sub>, H<sub>2</sub> and NaOH produced per hour vs current in brine electrolysis*

When the neighbour tests the solution remaining in the brine cell, he finds it has become strongly alkaline. He identifies a pungent, choking gas being released at one electrode and a colourless, flammable gas at the other. He also points out that the concentration of NaCl in the brine cell has fallen, and calculates how much copper should have deposited in the copper plating bath during the same 2-hour period using the same 3.0 A current, and finds that the actual mass deposited is significantly less than expected — suggesting that not all the current is being used for copper deposition (current efficiency problem). Faraday's constant  $F = 96\,485\text{ C mol}^{-1}$ .

Mrs Nalwoga's eldest child, a Senior 6 student, points out that the standard electrode potential of  $\text{Cu}^{2+}/\text{Cu}$  is +0.34 V and that of  $\text{Zn}^{2+}/\text{Zn}$  is -0.76 V. He wonders whether connecting the copper plating bath to a zinc electrode would create a spontaneous electrochemical cell and damage the equipment, and whether the cell voltage would change as the reaction proceeds.

The children also ask their mother why, during electrolysis of dilute sulphuric acid, oxygen gas is produced at the anode even though the solution contains  $\text{SO}_4^{2-}$  ions, and hydrogen is produced at the cathode even though  $\text{Cu}^{2+}$  ions are present in a copper sulphate solution. The neighbour explains this using the concept of discharge potential and the electrochemical series.

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**Task;**

As a chemistry learner, analyse this scenario and write a comprehensive scientific report addressing all the chemical issues, observations and calculations identified in the situation.

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## ITEM FOUR

### A MOTHER'S GARDEN

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Every Saturday morning, Mrs Achieng — a retired chemistry teacher turned fulltime farmer in Gulu — tends to her vegetable garden which she uses to feed her family and sell surplus produce at the local market. This Mother's Day, her four university-student children have come home to celebrate and find their mother dealing with a range of chemical challenges in her garden and household.

In the garden store, Mrs Achieng has several bags of chemicals: sodium chloride (NaCl), used to deter slugs; aluminium sulphate,  $\text{Al}_2(\text{SO}_4)_3$ , used to acidify soil for her blueberry plants; silicon dioxide ( $\text{SiO}_2$ ) sand used to improve drainage; phosphorus pentoxide ( $\text{P}_2\text{O}_5$ ) used as a desiccant; sulphur powder used as a fungicide; and a can of chlorine gas ( $\text{Cl}_2$ ) used to disinfect irrigation water. She also has a bottle of argon gas (Ar) used in a welding kit for repairing farm tools.

One of the sons, an engineering student, accidentally mixes a small amount of sodium with water from the irrigation hose and is shocked by the violent, fizzing reaction that produces a flammable gas and a strongly alkaline solution. His sister, a medical student, cuts herself on a piece of metal and uses dilute hydrochloric acid solution to clean the wound, then notices that the aluminium first-aid tin reacts with the HCl, producing a gas. Their mother calmly explains that the aluminium reaction is expected and asks her chemistry student son to explain why aluminium oxide behaves differently from sodium oxide when tested with both acid and alkali.

The chemistry student notices the following data on a periodic table reference card:

Property	Na	Mg	Al	Si	P	S
$\text{IE}_1 / \text{kJ mol}^{-1}$	496	738	578	786	1012	1000
Oxide formula	$\text{Na}_2\text{O}$	$\text{MgO}$	$\text{Al}_2\text{O}_3$	$\text{SiO}_2$	$\text{P}_2\text{O}_5$	$\text{SO}_3$
Oxide pH (aq)	13	9	Amphoteric	Acidic	Acidic	Acidic
Melting pt / $^\circ\text{C}$	98	650	660	1414	44	113

Later that afternoon, Mrs Achieng asks her chemistry son to prepare exactly 2.0 kg of a fertiliser mixture containing 15.0% nitrogen by mass, using ammonium sulphate  $(\text{NH}_4)_2\text{SO}_4$  as the nitrogen source, mixed with sand ( $\text{SiO}_2$ ) as filler. She also asks him to calculate how many molecules of  $\text{SO}_3$  are present in 4.0 g of sulphur trioxide, and to explain why sulphur dioxide produced by burning the sulphur fungicide is an environmental pollutant that can lead to acid rain.

As evening falls, the family discusses why chlorine gas — despite being denser than air and highly toxic — is used in water treatment, and what volume of chlorine at s.t.p would be needed to treat 1000 dm<sup>3</sup> of irrigation water if the required concentration is  $2.0 \times 10^{-4}$  mol dm<sup>-3</sup>. Mrs Achieng points out that her ionisation energy reference card shows two unexpected drops across Period 3 — at aluminium and at sulphur — which she used to teach her students for 30 years, and challenges her children to explain them before dinner.

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**Task;**

As a chemistry learner, analyse this scenario and write a comprehensive scientific report addressing all the chemical issues, observations and calculations identified in the situation.

## Part II

*Respond to only ONE item from this part.*

### ITEM FIVE

#### MOTHER'S COSMETICS LABORATORY

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Mrs Tendo is an entrepreneurial mother in Kampala who runs a small cosmetics and personal care products business from her home laboratory. She produces lotions, perfumes, and cleaning agents using organic chemicals sourced from industrial suppliers. This Mother's Day, her daughter Grace — a Senior 6 chemistry student — has come home and is fascinated by the chemistry happening in her mother's workshop.

In one corner of the workshop, Mrs Tendo is manufacturing a polymer-based moisturising lotion. She has a cylinder of ethene gas ( $C_2H_4$ ) connected to a high-pressure reactor vessel containing a Ziegler-Natta catalyst. Grace notices that the colourless ethene gas is being converted into a white, waxy solid that her mother then dissolves in a carrier oil to make the lotion base. Grace checks the label and confirms the solid is low-density polythene (LDPE).

On the workbench, Grace finds three unlabelled bottles — X, Y and Z — each containing a colourless liquid organic compound. Her mother explains that one is ethanol ( $C_2H_5OH$ ), one is a liquid alkene she uses as a fragrance intermediate, and one is ethanoic acid ( $CH_3COOH$ ) used as a preservative. Grace sets up a series of tests: she adds a few drops of each to separate portions of orange bromine water, acidified  $KMnO_4$  solution, sodium carbonate solution, and litmus solution. She records the following observations:

Test	X	Y	Z	
Bromine water	No change	Immediate decolourisation	No change	
Acidified $KMnO_4$	No change	Decolourised	No change	
$Na_2CO_3$ solution	No change	No change	Effervescence	
Litmus	Neutral	Neutral	Turns red	

Grace then picks up the liquid alkene (bottle Y) and attempts to make a new fragrance ester by reacting it with ethanoic acid in the presence of a few drops of concentrated sulphuric acid and heating gently. Instead of an ester, however, she gets a different product — the alkene appears to have reacted with the water in the ethanoic acid solution through a different pathway.

Mrs Tendo explains that the alkene in bottle Y is but-2-ene ( $\text{CH}_3\text{CH}=\text{CHCH}_3$ ) and shows Grace a reference sheet with the enthalpy cycle for its reactions. She explains that but-2-ene can react with HBr via electrophilic addition and asks Grace to predict the major product when HBr is added to an unsymmetrical alkene like propene, explaining the role of Markovnikov's rule and carbocation stability.

In another part of the workshop, Mrs Tendo is distilling a mixture of ethanol and water to purify the ethanol used in her perfumes. Grace is puzzled when her mother tells her that 100% pure ethanol cannot be obtained by simple distillation alone, because the mixture forms an azeotrope at 95.6% ethanol. Grace's mother also explains that ethanol can be oxidised to ethanoic acid using acidified potassium dichromate, and that ethanoic acid can be further converted to useful derivatives such as esters and acid chlorides.

Finally, Grace finds a combustion analysis report on the workbench. It states that 0.60 g of compound T — a fragrance ingredient her mother synthesised — was completely combusted to give 1.76 g of  $\text{CO}_2$  and 0.72 g of  $\text{H}_2\text{O}$ . A separate vapour density experiment gave a molar mass of  $60 \text{ g mol}^{-1}$  for compound T. Her mother says the compound is also an ester and asks Grace to determine its molecular formula and suggest a possible structure.

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### **Task;**

As a chemistry learner, analyse this scenario and write a comprehensive scientific report addressing all the chemical issues, observations and calculations identified in the situation.

## ITEM SIX

### THE WARMTH OF A MOTHER'S KITCHEN

In Rukungiri district, Mrs Kyomugisha is a hardworking mother of seven who cooks three meals a day for her family using a wood-burning clay stove. On this Mother's Day, her son Emmanuel — a university chemistry student — has returned home and is determined to help his mother find a cheaper and cleaner fuel. He sets up a simple calorimetry experiment in the kitchen using a copper calorimeter (mass 150 g, specific heat capacity  $0.39 \text{ J g}^{-1} \text{ K}^{-1}$ ) containing  $200 \text{ cm}^3$  of water.

Emmanuel burns exactly 0.50 g of dry firewood (which he treats as pure carbon for simplicity) and 0.50 g of methane ( $\text{CH}_4$ ) separately, transferring the heat to the calorimeter in each case. For the carbon sample, the temperature of the water rises from  $20.0^\circ\text{C}$  to  $38.5^\circ\text{C}$ . For the methane sample, the temperature rises from  $20.0^\circ\text{C}$  to  $52.3^\circ\text{C}$ . The standard enthalpy of combustion of carbon is  $-393.5 \text{ kJ mol}^{-1}$  and that of hydrogen is  $-286.0 \text{ kJ mol}^{-1}$ .

Emmanuel wants to calculate the enthalpy of combustion of methane using Hess's Law and an enthalpy cycle, without directly measuring it, using only the standard enthalpies of formation of  $\text{CO}_2(\text{g})$  and  $\text{H}_2\text{O}(\text{l})$ . The energy cycle diagram below illustrates the Hess's Law principle he plans to use:

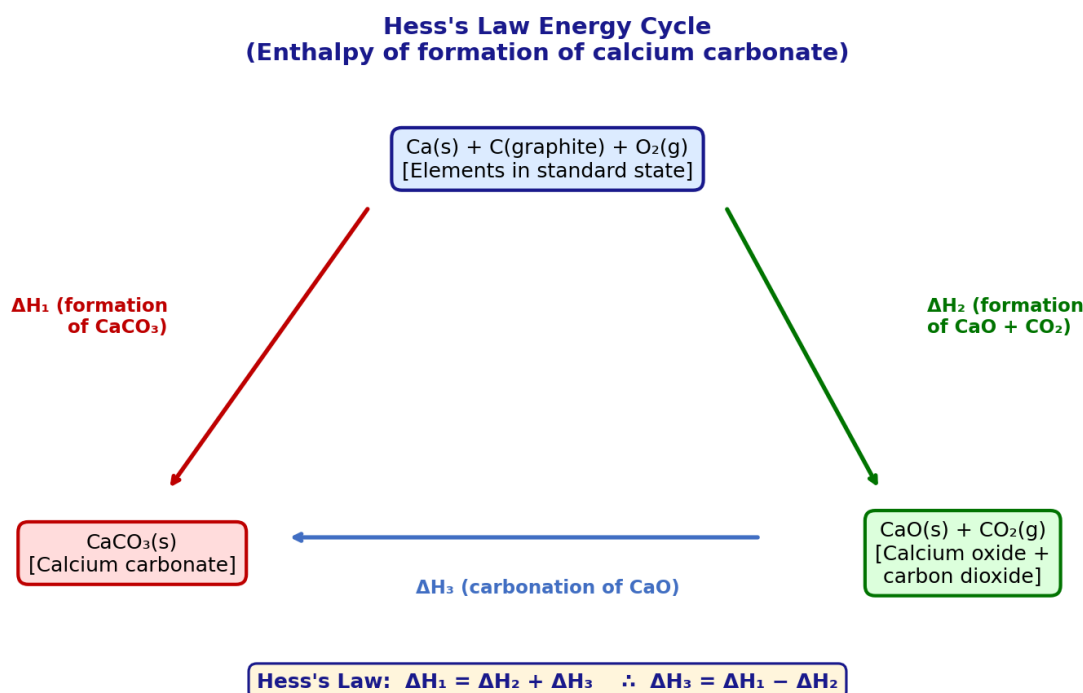


Fig. 6: Hess's Law energy cycle for calculating enthalpy of formation

His mother is also concerned about the black smoke produced by the wood fire, which she knows is harmful to her lungs. Emmanuel explains that incomplete combustion of carbon produces carbon monoxide and unburned carbon particles (soot), while complete combustion produces only  $\text{CO}_2$  and  $\text{H}_2\text{O}$ . He writes the balanced equations for both types of combustion and calculates the difference in energy released per mole of carbon in each case.

Later, Emmanuel measures  $2.24 \text{ dm}^3$  of methane gas at s.t.p and dissolves 6.0 g of NaOH in  $100 \text{ cm}^3$  of water in a separate experiment, noticing that the water becomes warm — indicating an exothermic dissolution process. His younger sister asks why some substances dissolve exothermically and others endothermically, and he explains using the concepts of lattice enthalpy and hydration enthalpy.

Emmanuel also investigates whether switching from firewood to liquefied petroleum gas (LPG, treated as propane  $\text{C}_3\text{H}_8$ ) would be cost-effective for his mother. He calculates the heat released per gram of each fuel and compares the values. He notes that the standard enthalpy of combustion of propane is  $-2220 \text{ kJ mol}^{-1}$ , while that of carbon (as used for firewood approximation) is  $-393.5 \text{ kJ mol}^{-1}$ . He also explains to his mother that the C—H and C—C bond enthalpies in propane (C—H:  $413 \text{ kJ mol}^{-1}$ ; C—C:  $347 \text{ kJ mol}^{-1}$ ; O=O:  $498 \text{ kJ mol}^{-1}$ ; C=O:  $805 \text{ kJ mol}^{-1}$ ; O—H:  $464 \text{ kJ mol}^{-1}$ ) can be used to estimate the enthalpy of combustion of propane using a bond enthalpy calculation.

As a final gift to his mother, Emmanuel prepares a summary comparing the energy efficiency, environmental impact, cost, and safety of firewood, charcoal (carbon), methane (biogas) and LPG (propane) for household cooking, and presents it as a written report dedicated to his mother on Mother's Day.

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### Task;

As a chemistry learner, analyse this scenario and write a comprehensive scientific report addressing all the chemical issues, observations and calculations identified in the situation.



**Happy Mother's Day to all the incredible mothers!**

*"Behind every great student stands a mother who believed first."*



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# THE PERIODIC TABLE

1	2											3	4	5	6	7	8/0
1.0 H 1																1.0 H 1	4.0 He 2
6.9 Li 3	9.0 Be 4											10.8 B 5	12.0 C 6	14.0 N 7	16.0 O 8	19.0 F 9	20.2 Ne 10
23.0 Na 11	24.3 Mg 12											27.0 Al 13	28.1 Si 14	31.0 P 15	32.1 S 16	35.4 Cl 17	40.0 Ar 18
39.1 K 19	40.1 Ca 20	45.0 Sc 21	47.9 Ti 22	50.9 V 23	52.0 Cr 24	54.9 Mn 25	55.8 Fe 26	58.9 Co 27	58.7 Ni 28	63.5 Cu 29	65.7 Zn 30	69.7 Ga 31	72.6 Ge 32	74.9 As 33	79.0 Se 34	79.9 Br 35	83.8 Kr 36
85.5 Rb 37	87.6 Sr 38	88.9 Y 39	91.2 Zr 40	92.9 Nb 41	95.9 Mo 42	98.9 Tc 43	101 Ru 44	103 Rh 45	106 Pd 46	108 Ag 47	112 Cd 48	115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
133 Cs 55	137 Ba 56	*	178 Hf 72	181 Ta 73	184 W 74	186 Re 75	190 Os 76	192 Ir 77	195 Pt 78	197 Au 79	201 Hg 80	204 Tl 81	207 Pb 82	209 Bi 83	209 Po 84	210 At 85	222 Rn 86
223 Fr 87	226 Ra 88	**															

*End*

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