

SECTION A [40 MARKS]
ANSWER ALL QUESTIONS

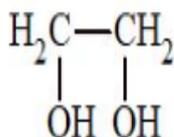
Question 1

a) For each question, there are FOUR responses: A, B, C and D. Choose the corresponding letter of your response and CIRCLE it neatly. NO score will be awarded if you circle more than ONE letter. [25]

i. Halogens are generally found in all states of matter. The halogen which is liquid at room temperature is

- A astatine.
- B bromine.
- C chlorine.
- D fluorine.

ii. The structural formula shown below represents a type of alcohol.



Identify the class of alcohol.

- A Monohydric alcohol
- B Dihydric alcohol
- C Trihydric alcohol
- D Tetrahydric alcohol

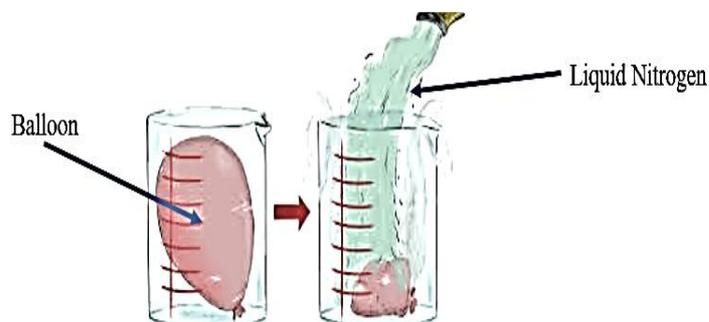
iii. The behavior of ideal gases is based on three basic gas laws. These laws are

- A Boyle's law, Charles' law and Avogadro's law.
- B Boyle's law, Charles' law and Gay Lussac's law.
- C Boyle's law, Avogadro's law and Gay Lussac's law.
- D Charles' law, Avogadro's law and Gay Lussac's law.

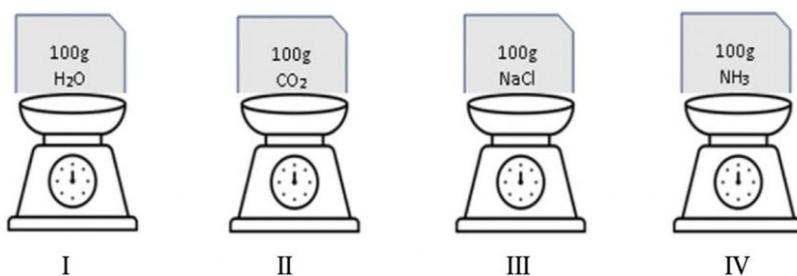
iv. Transition elements are widely used as catalysts in various chemical industries. This is due to

- A their ability to absorb and react with substance.
- B their ability to absorb and activate reacting substance.
- C their vacant d-orbitals to adsorb and activate reacting substances.
- D their vacant d-orbitals to accept lone pairs from reacting substances.

- v. A group of science students are conducting an experiment with a balloon filled with air. They put the balloon inside a container and pour liquid nitrogen over the balloon as shown in the figure. When the liquid nitrogen is poured, the balloon changes the volume due to change in temperature. Which of the following relationship is true?

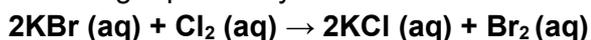


- A $V \propto P$
 B $V \propto \frac{1}{P}$
 C $V \propto T$
 D $V \propto \frac{1}{T}$
- vi. In the laboratory, a teacher demonstrates a neutralization reaction to the class by mixing sodium hydroxide and hydrochloric acid. The chemical equation for the reaction is:
- A $\text{HCl} + \text{NaOH} \rightarrow \text{H}_2\text{O} + \text{Na}_2\text{CO}_3$
 B $\text{HCl} + \text{NaOH} \rightarrow \text{H}_2\text{O} + \text{NaCl}$
 C $\text{HCl} + \text{NaOH} \rightarrow \text{H}_2 + \text{NaOH}$
 D $\text{HCl} + \text{NaOH} \rightarrow \text{H}_2\text{O} + \text{NaNO}_3$
- vii. Study the figure below and determine which of the following compounds has the greatest number of moles in a 100 g sample.



- A I
 B II
 C III
 D IV

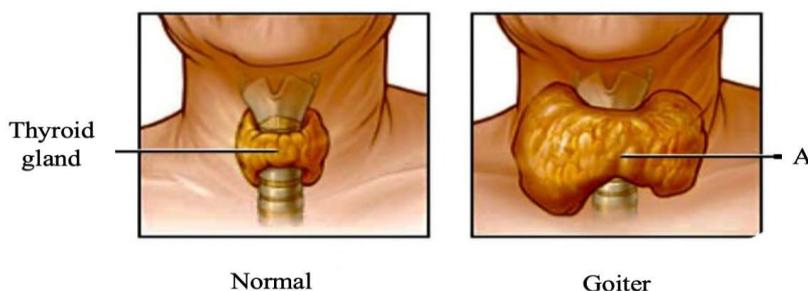
- viii. The reaction shown below illustrates a displacement reaction of halogen where bromine is being replaced by chlorine.



In this reaction:

- A Cl is more electronegative than Br
B Cl is less electronegative than Br
C Cl is more electropositive than Br
D Cl is less reactive than Br
- ix. The IUPAC name of the compound with the structural formula $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ is
- A Butanol.
B Ethanol.
C Methanol.
D Propanol.
- x. If you were tasked with concentrating tin ore from a mine where impurities such as quartz and feldspar are lighter than the tin ore particles, which method would you employ?
- A leaching
B levitation
C magnetic separation
D froth floatation process
- xi. A gas occupies a volume of 500 mL at a pressure of 800 mmHg. If the pressure is increased by 40% of its initial pressure, what will be the new volume of the gas?
- A 357 mL
B 375 mL
C 700 mL
D 1000 mL
- xii. Nima was instructed to write the electronic configuration of a magnesium atom using s p d f notation. Which of the following configurations is likely to be Nima's answer?
- A $1s^2 2s^2 2p^6$
B $1s^2 2s^2 2p^6 3s^2$
C $1s^2 2s^2 2p^6 3s^2 3p^6$
D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4 4s^2$
- xiii. Element X constitutes 18.6% of the total composition of the compound with molecular formula $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$. This element is
- A calcium.
B hydrogen.
C oxygen.
D sulphur.

- xiv. In a chemistry experiment, Pema dissolved ammonium nitrate in water to study a certain type of reaction. After the reaction, the temperature of the solution was found to be lower than the initial temperature. The type of reaction in Pema's experiment is
- A a neutral reaction.
 B an exothermic reaction.
 C a displacement reaction.
 D an endothermic reaction.
- xv. In Bhutan, alcohol has been a part of the culture, where it is used for various purposes in almost all occasions and celebrations. However, the sale of alcohol to children under 18 years is restricted by law. What could be the primary reasons for this regulation?
- A To ensure that individuals are financially independent
 B To prevent underage drinking and related health issues
 C To increase alcohol sales by targeting older demographics
 D To encourage responsible drinking habits from a young age
- xvi. A LPG cylinder contains 10 L of gas at STP. If 1 L of the gas contains molecules equal to Avogadro's number, the number of molecules present in the gas cylinder is
- A $5 \times 6.023 \times 10^{22}$.
 B $5 \times 6.023 \times 10^{23}$.
 C $10 \times 6.023 \times 10^{22}$.
 D $10 \times 6.023 \times 10^{23}$.
- xvii. The homogeneous mixture of metals or a metal and a non-metal, which cannot be separated by physical means is called
- A alloy.
 B flux.
 C gangue.
 D slag.
- xviii. During classroom discussion on nutritional diets, the teacher highlights the importance of a specific halogen for thyroid hormone production, which controls metabolism, growth, and energy levels. Insufficient intake of this halogen can lead to thyroid disorders depicted as labeled **A** in the figure.



Identify the halogen that may be used for treating thyroid disorders.

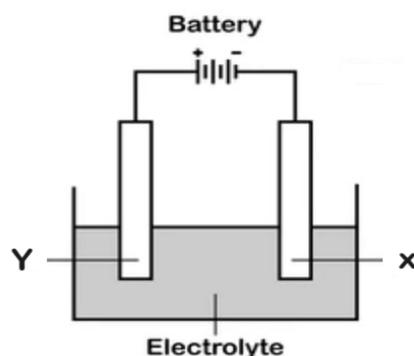
- A Bromine
- B Chlorine
- C Fluorine
- D Iodine

xix. According to an international news agency, at least 34 people have died and dozens more are being treated in hospitals after consuming illicit alcohol in the southern Indian state of Tamil Nadu. A state government spokesperson confirmed on Thursday that the deaths were caused by consuming spurious liquor (Al Jazeera, 2024, June 20).

What toxic component in illicit alcohol led to deaths and hospitalizations, according to authorities?

- A Ethanol
- B Glycerin
- C Methanol
- D Yeast

xx. The setup depicted in the figure below illustrates the electro-refining of impure copper.



Which of the following statements accurately describes about an electrode X?

- A X is the anode and its size will increase
- B X is the anode and its size will decrease
- C X is the cathode and its size will increase
- D X is the cathode and its size will decrease

xxi. In traditional Bhutanese culture, before the introduction of paper currency, the minting of coins from transition elements was a revered practice. The cultural significance of these coins was further emphasized as they were exchanged by locals as symbols of prosperity and blessings during the annual harvest festival.

Which transition element was commonly used as coin during that period?

- A Cobalt
- B Copper
- C Lead
- D Zinc

xxii. Zangmo was investigating compound Y and discovered that it has a relative molecular mass of 60. Which compound was Zangmo studying?

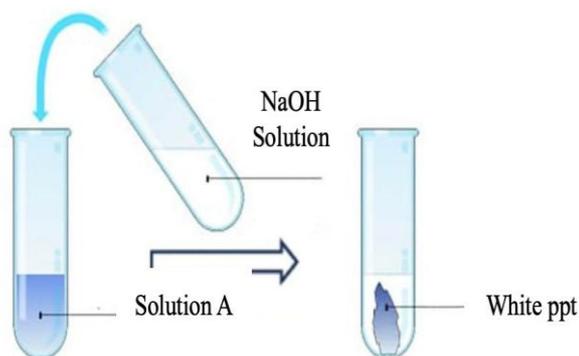
- A H_2SO_4
- B CaCO_3
- C $\text{C}_2\text{H}_5\text{OH}$
- D CH_3COOH

xxiii. During a festive gathering in Bhutan, Ugyen observed children playing with helium-filled balloons. Suddenly, one of the balloons burst when someone accidentally sat on it.

What caused the balloon to burst when someone sat on it?

- A Temperature decrease
- B Helium expansion
- C Pressure increase
- D Chemical reaction

xxiv. When NaOH solution is added to the beaker containing solution **A** as indicated in the figure below, a white precipitate is formed.



The precipitate dissolves on addition of excess NaOH, resulting in a colourless solution.

What could solution **A** be?

- A Salt of Iron
- B Salt of Zinc
- C Salt of Copper
- D Salt of Manganese

xxv. The volume occupied by 28 g of nitrogen at STP will be

- A 11.2 mL
- B 22.4 mL
- C 11.2 L
- D 22.4 L

b) Fill in the blanks with appropriate word (s).**[5]**

i.	At a constant temperature, if the volume of a gas is compressed from 2 L to 1 L, the pressure will increase from 760 mm Hg to _____.	
ii.	A naturally occurring rock or mineral from which a metal or valuable mineral can be extracted economically is called _____.	
iii.	Elements in the periodic table are classified into four blocks. An element with atomic number 19 belongs to the _____ block.	
iv.	A compound has an empirical formula of CH_2 , and its molecular formula is C_2H_4 . The molecular formula is a simple multiple of the _____.	
v.	During the combustion of wood, the enthalpy of reaction is always less than _____.	

c) Write TRUE or FALSE for the following statements in the space provided in the 'Answer' column.**[5]**

i.	A sample of helium occupying 140 cm^3 at 8 atm will occupy a larger volume when the pressure is decreased to 6 atm at constant temperature.		
ii.	A tincture of bromine is used as a disinfectant for cleaning wounds.		
iii.	Gold is commonly used in jewelry due to its resistant to tarnish when they come in contact with oxygen and moisture.		
iv.	The solubility of ethyl alcohol in water is due to the formation of intermolecular hydrogen bonding.		
v.	The gram molecular mass of table salt is 40 g.		

- d) Match each item in Column A with the most appropriate item in Column B. [5]
Write the correct letter in the space provided in the 'Answer' column.

Column A	Column B	Answer
i. The value of 15°C temperature in kelvin scale	a. Copper	i.
ii. Law of conservation of energy	b. Ethanol	ii.
iii. The element used in non-sticky cooking pans	c. E = zero	iii.
iv. The chemical substance used as biofuel	d. 288 K	iv.
v. The value of standard temperature	e. Fluorine	v.
	f. 273 K	
	g. E > zero	

SECTION B [60 MARKS]
ATTEMPT ANY SIX QUESTIONS

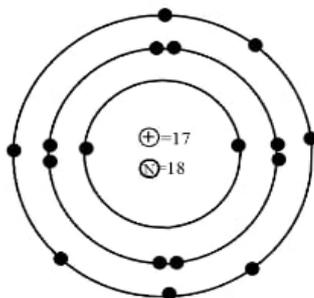
Question 2

- a) A sealed plastic bottle is partially filled with air and left at room temperature (25°C). The bottle is then placed inside a refrigerator where the temperature is 4°C.
- i. What changes will be observed in a sealed plastic bottle when it is placed inside a refrigerator? **[1]**

- ii. Which gas law explains this phenomenon? Justify your answer. **[1]**

- b) While carrying out the laboratory investigation, a student uses ethyl alcohol, acetic acid and concentrated sulphuric acid. Describe the chemical reaction involved in the process to produce ethyl acetate from ethanol and acetic acid with chemical equation. **[2]**

- c) The figure given below represents an atom of a certain element. Study the figure and answer the questions that follow:



- i. Predict the possible ion formation by the element with the help of electron dot diagram. **[1]**

- ii. Name the type of chemical bond formed between the element and sodium atom. **[1]**

- d) Metals like iron and aluminum are commonly used in the construction of buildings. Describe **TWO** specific ways in which the properties of metals provide advantages for constructing buildings. **[2]**

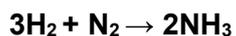
- e) Metals are arranged in a vertical column in the decreasing order of their reactivity, known as the metal activity series. The extraction process of metals varies based on their position in the activity series.

- i. Name the method used for extracting highly reactive metals like potassium and sodium. **[1]**

- ii. Explain why is this extraction method suitable for highly reactive metals such as potassium and sodium. **[1]**

Question 3

a) Hydrogen gas reacts with nitrogen gas to form ammonia according to the equation



If 25.0 grams of ammonia are produced, determine the mass of nitrogen gas required for the reaction at STP.

[2]

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b) Differentiate the following pairs based on the information provided in the bracket.

i. Boyle's Law and Charles' Law **[Variable kept constant]**

[1]

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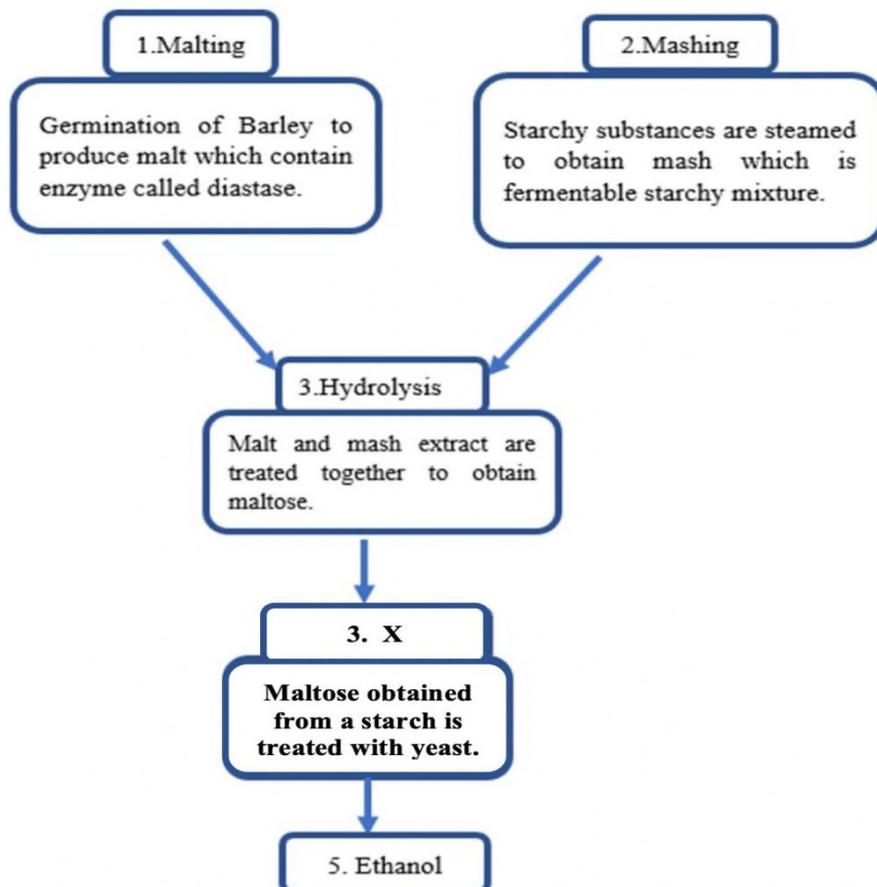
ii. Enthalpy and Entropy **[Definition]**

[1]

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- c) People often encounter with common dental problems such as cavities and gum diseases. Imagine yourself as a dental specialist assigned to formulate a toothpaste that may be recommended to people with dental problems. What type of toothpaste would you recommend for the people? Give appropriate reason for this recommendation. [2]

- d) The flow chart below shows the steps involved in the preparation of ethanol from starch by fermentation. Study the diagram and answer the questions that follow.



- i. Name the Process represented by X. [1]

- ii. Explain the process X with balance chemical equation. [1]

- e) As an alternate source of energy, many countries utilize methane and alcohol to meet energy demands in a sustainable and cost-effective manner. Discuss **ONE** significant benefits of methane in human society, particularly in terms of its contributions to energy production. Support your answer with chemical equation. [2]

Question 4

- a) During the extraction of iron in a metallurgical industry, the ore of iron is initially crushed into fine powder which may contain impurities such as silica, clay, and other non-magnetic materials.
- i. If you were an expert in metallurgy, which concentration method would you suggest for efficiently extracting iron from its ore? [1]

- ii. Create a labelled diagram illustrating the setup for concentrating ore and separating it from its impurities. **[1]**

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- b) A student is given a piece of iron and asked to study its magnetic properties. As a part of the study, the student places the iron piece in an external magnetic field. When the magnetic field was removed, the piece of iron continues to attract magnetic materials.

- i. What can the student conclude about the magnetic property of iron? **[1]**

- ii. Name **ONE** device where permanent magnets play a crucial role. **[1]**

- c) Which has a greater number of atoms, 150 g of calcium or 150 g of copper (Cu= 64)? **[2]**

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- d) During the pandemic, general public were advised to use hand sanitizers frequently to avoid the spread of infection. In certain cases where there was no availability of hand sanitizers, people were encouraged to prepare their own hand sanitizer using locally available materials.

Name the alcohol commonly used for making hand sanitizer. What is recommended percentage composition of alcohol in hand sanitizer?

[2]

- e) 2 g of H₂ and 32 g of O₂ occupy equal volume at STP.

Is this statement true or false? Prove it with calculation.

[1]

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- f) Is the reaction of H₂ and O₂ exothermic or endothermic in nature. Design a suitable energy diagram.

[1]

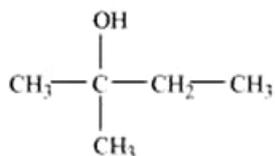
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Question 5

- a) In a certain household, a family was using kitchen sink made up of iron which was rusting fast. As a metallurgist, suggest an alloy that can replace the iron sink to overcome the problem of rusting. Give a reason. [2]

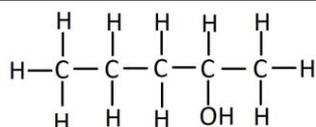
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- b) Write the IUPAC name for the following compounds [1]



i.

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ii.

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- c) Complete the table given below. [2]

Element	Electronic configuration (s, p, d, f notation)	Belongs to which block of the periodic table
Sodium	$1s^2 2s^2 2p^6 3s^1$	s-block
Carbon	i.	ii.
Manganese	iii.	iv.

- d) Electrolytes generally undergo dissociation reaction to produce respective ions during electro-refining process of metals. Study and complete the table given below: **[2]**

Electrolyte	Dissociation equation	Cation	
CuSO_4	i.	ii.	
AgNO_3	iii.	iv.	

- e) An unknown compound has a molar mass of approximately 90 g/mol and contains 54.5% carbon, 9.1% hydrogen, and 36.4% oxygen by mass. Determine the empirical formula of the compound based on these percentages. **[3]**

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Question 6

- a) A scuba diver is planning a deep-sea dive to explore a shipwreck. To ensure safety, the diver needs to calculate the amount of air (oxygen and nitrogen mixture) required for the dive, considering the depth and duration under water.

Given data:

- I. The diver plans to dive to a depth of 30 meters where pressure is 3 atm
- II. The diver's air tank has a volume of 12 litres.
- III. The temperature during the dive is expected to be around 20°C.
- IV. The air mixture behaves ideally.

What would be the expected amount of gas in diver's tank?

[2]

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- b) Following are the molecular formulae of organic compounds.

C_3H_8O , $C_2H_2O_4$, CH_2O , $C_4H_4O_8$, C_2H_6O

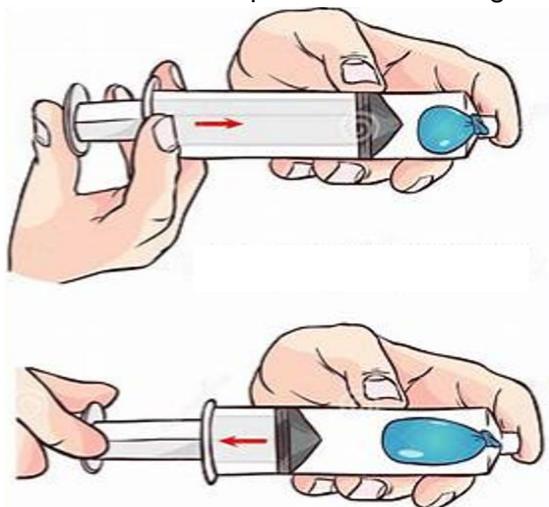
- i. Select **TWO** possible molecular formulae that could correspond to the empirical formula CHO_2 .

[1]

ii. Define molecular formula.

[1]

c) The figure below illustrates a concept from one of the gas laws.



Study the figure and explain how this law applies to the process of breathing. Describe what happens to lungs during inhalation and exhalation.

[2]

d) Study the figure below, and fill up the table that follows.

[2]

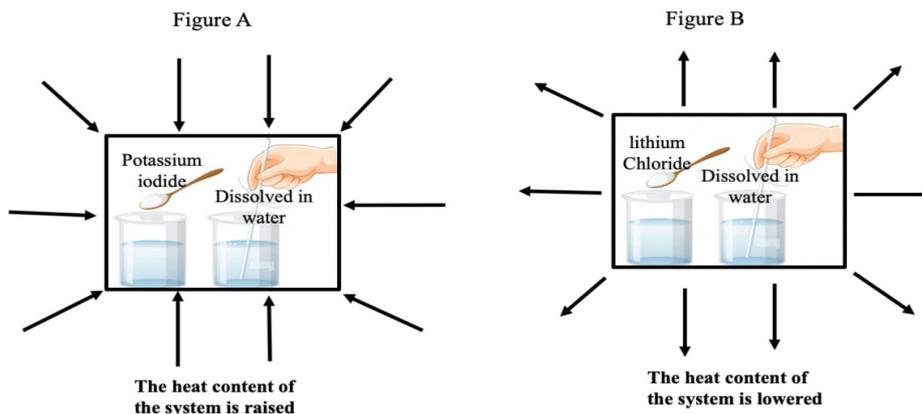


Figure	Thermochemical reaction	$\Delta H =$ (positive /negative)	
A	i.	iii.	
B	ii.	iv.	

e) Alcohol contains psychoactive substances that can cause health issues and social problems.

i. Should alcohol be banned in Bhutan due to health and social issues? Provide a reason to support your answer.

[1]

ii. What is the effect of alcohol on the central nervous system?

[1]

Question 7

a) A group of boys goes swimming every weekend in swimming pool. After a few months, they notice their swimsuits have faded. They are unhappy with it and are trying to figure out the cause.

i. What is the cause of fading of the color? **[1]**

ii. A certain chemical substance is regularly added to swimming pool. Give reasons. **[1]**

b) Flame tests for metals have several practical applications in real life across various fields.

Explain **ONE** application of flame test in forensic science. **[2]**

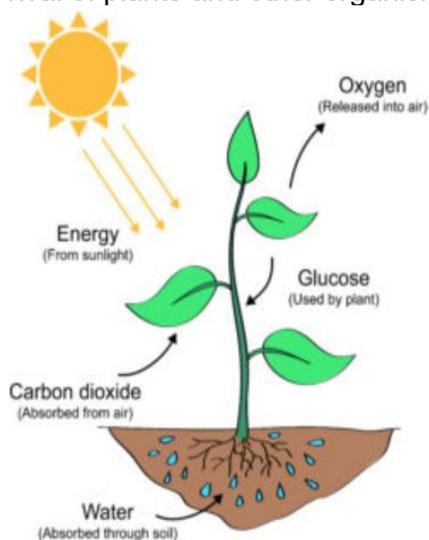
c) All the elements of d-blocks are not transition elements but all the transition elements are d-block elements.

i. Is scandium transition element? Give a reason. **[1]**

ii. Why do transition elements show variable oxidation states? [1]

d) Alcohols are hydroxy derivatives of alkanes, composed of an alkyl group and a hydroxyl group.
 What do you understand by alkyl group. Name the corresponding alkyl for methanol and ethanol. [2]

e) The figure below represents the biochemical reaction which is necessary for the growth and survival of plants and other organisms.



Explain with chemical reaction how this reaction contributes to the survival of plants. [2]

Question 8

- a) Design an experiment to detect the presence of alcohol in the human body using the materials given in the table below. Your design should include the aim, procedure and result. **[2]**

Apparatus	Chemicals
<ul style="list-style-type: none"> • Test tubes • Dropper • Safety goggles • Gloves 	<ul style="list-style-type: none"> • Ethanol solution • Distilled water • Potassium dichromate solution • H₂SO₄

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- b) A sample of gas at 1 atm had a volume of 1.6 L at 100 °C. What would its volume be at 0 °C and 600 mm Hg pressure? **[2]**

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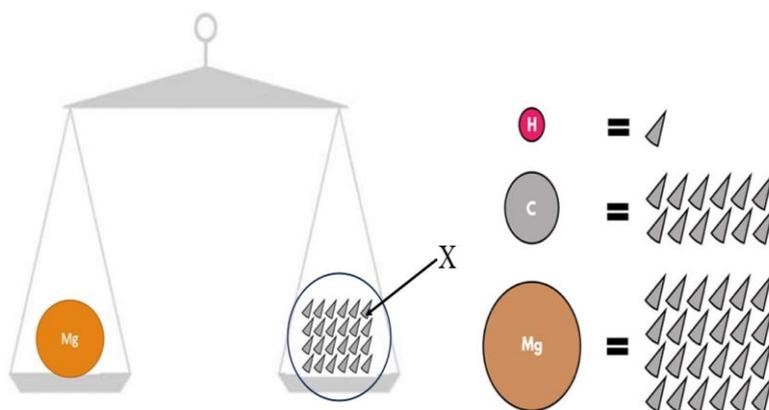
- c) The concept of the mole allows chemists to quantify and compare the amounts of substances in chemical reactions based on their atomic or molecular weights.
- i. How does the concept of the mole enable chemist to accurately measure and compare the quantities of substances involved in chemical reactions? **[1]**

- ii. Provide **TWO** real life examples where the mole concept is used to measure and compare quantities of substance in chemical reactions? **[1]**

- ii. Calculate the effective nuclear charge experienced by the electrons of sodium atom in second or L-shell. **[1]**

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- b) Element X given in the figure below is used to compare the relative atomic mass of an element. **[2]**



Identify element X. What do you understand by the statement "the relative atomic mass of magnesium is 12 a.m.u"?

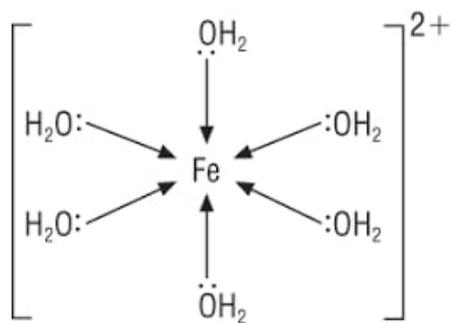
- c) A gas has a pressure of 1.5 atm at 300 K. If the temperature is increased to 550 K, what is the new pressure? **[2]**

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- d) Is 66 g of CO_2 equal to 1.5 moles of CO_2 at STP? Prove it. **[2]**

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- e) The figure given below represents the coordination complex of iron. Study the figure and answer the following questions.



- i. How is the bond between the central atom, Fe and the ligand, H_2O formed in the complex? **[1]**

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ii. Name the bond linking the ligand to the central metal atom.

[1]
