SECTION A [40 MARKS]

ANSWER **ALL** QUESTIONS

Question 1 **[25]**

a) Direction: For each question, there are four alternatives A, B, C and D. Choose the correct alternative and CIRCLE it. Do not circle more than ONE alternative. If there is more than one circled, NO score will be awarded.

i. An organic compound characterized by one or more hydroxyl groups attached to a carbon atom of hydrocarbon chain is

A ester.
B ketone.
C alcohol.
D aldehyde.

ii. The correct electronic configuration of an element having atomic number 17 is

A 1s2 2s2 2p5 3s2 3p6.
B 1s2 2s2 2p6 3s1 3p6.
C 1s2 2s2 2p6 3s2 3p5.
D 1s2 2s2 2p5 3s3 3p5.

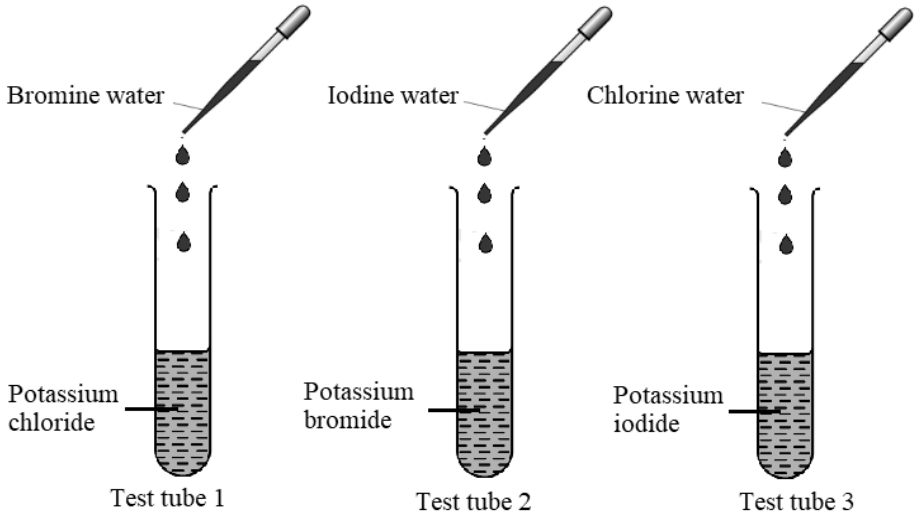
iii. Sonam investigated Charles's law by performing an experiment. Table below shows the record of her experiment.

Experiment	**Temperature (K)**		**Volume (mL)**	
	Initial	**Final**	**Initial**	**Final**
Round 1	300	330	200	220
Round 2	280	250	140	160
Round 3	450	400	225	200
Round 4	320	400	160	200

An error in the findings was observed in round

A 1.
B 2.
C 3.
D 4.

iv. Study the figure to determine the displacement reaction of halogens with various halide solutions.



The reaction would occur in

A test tube 1.
B test tube 2.
C test tube 3.
D test tube 1 and test tube 2.

v. The number of hydrogen atoms present in ethyl alcohol is

A 4.
B 5.
C 6.
D 7.

vi. Tashi checked his body temperature with a thermal scanner before entering the school campus. If his body temperature reads 35°C, the reading on the Kelvin scale would be

A 308 K.
B 273 K.
C 238 K.
D 100 K.

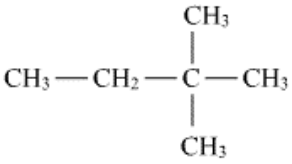
vii. Titanium is often used to replace fractured bones in our body because it is

A light.
B heavy.
C cheap.
D corrosive.

viii. Generally people use alcohol based hand sanitizers in the absence of soap and water to reduce the risk of spreading corona virus. This is because alcohol has

A reducing property.
B oxidising property.
C antibiotic property.
D antimicrobial property.

ix. Study the structural formula of the hydrocarbon given below.



The IUPAC name of the hydrocarbon is

A 2, 2-methyl butane.
B 2, 2-dimethyl butane.
C 1, 1, 1-trimethyl propane.
D 2-ethyl-2-methyl butane.

x. Silver, platinum and gold are used for making ornaments. These metals are found in their native state in nature because they are

A rare.
B expensive.
C least reactive.
D highly reactive.

xi. Metallic cans are often used for packing beverages because of its advantages. However, some of the metals are toxic and harmful. One such toxic metal is

A tin.
B lead.
C copper.
D chromium.

xii. The effective nuclear charge is the net positive charge experienced by valence electrons. If the shielding electron increases, the effective nuclear charge would

A increase.
B decrease.
C remains same.
D be in negative value.

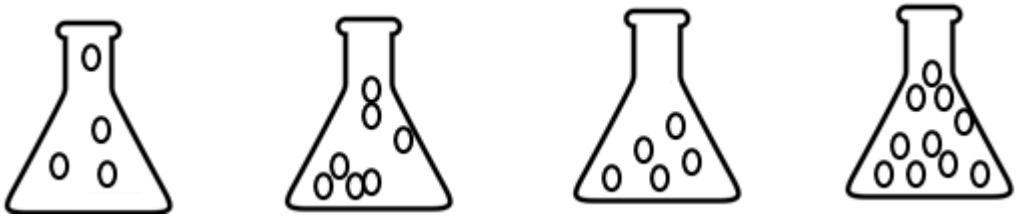
xiii. Table below shows the boiling points of group 17 elements.

Element	Boiling Point (K)
Iodine	458
Bromine	X
Fluorine	85
Astatine	610
Chlorine	239

The value of "X" in the table would be

A 162.
B 332.
C 534.
D 466.

xiv. The figure below shows conical flasks containing different number of gas molecules kept under the same temperature.



Flask 1 Flask 2 Flask 3 Flask 4

The flask with the minimum pressure is

A flask 1.
B flask 2.
C flask 3.
D flask 4.

xv. In the periodic table, the location of transition elements is in between

A lanthanides and actinides.
B s- and p-block elements.
C d- and f-block elements.
D chalcogens and halogens.

xvi. In the chemical reaction, **Fe(s) + 2HCl(aq) →$FeCl_2$ (aq) + <u>gas</u>,** the gas evolved is

A helium.
B oxygen.
C chlorine.
D hydrogen.

xvii. Lead nitrate ($PbNO_3$) is used in the manufacture of matches and explosives. When it reacts with potassium iodide (KI) in an aqueous solution, the reaction it undergoes is

A displacement.
B neutralization.
C decomposition.
D double displacement.

xviii. Glucose ($C_6H_{12}O_6$) is one of the main sources of energy. The percentage of hydrogen present in a glucose molecule is

A 8.3%.
B 6.6%.
C 40.0%.
D 53.3%.

xix. Arrange the following gases in increasing order of their masses.
I. 1.0 mole of O_3
II. 1.0 mole of N_2
III. 1.0 mole of O_2
IV. 1.0 mole of CO_2

A II < III < IV < I
B II < III < I < IV
C IV < II < III < I
D I < II < III < IV

xx. Table salt (NaCl) is one of the basic ingredients that adds flavor to the food. However, consuming excess salt leads to high blood pressure, heart disease and stroke. If a doctor recommends you to take 3 grams daily, how much salt molecules would you be consuming in a day?

A 6.023×10^{21}
B 3.088×10^{22}
C 1.809×10^{23}
D 5.420×10^{24}

xxi. Four students calculated the molecular masses based on the chemical formulae as shown in the table.

Student	Chemical formula	Molecular mass
A	CO	12 + 16 = 28
B	HCl	1 + 35.5 = 36.5
C	H_2O	1x1 + 16 = 17
D	NO	14 + 16 = 30

Which student got the wrong molecular mass of the given compound?

A student A
B student B
C student C
D student D

xxii. The amount of heat transferred to convert unit mass of solid to vapour or vice versa is known as the heat of

A formation.
B evaporation.
C sublimation.
D neutralization.

xxiii. A fire extinguisher cylinder contains 792 grams of carbon dioxide gas. The moles of carbon dioxide gas in a cylinder is

A 17.
B 18.
C 36.
D 40.

xxiv. Table below represents four different chemical reactions with their enthalpy values.

Reaction No.	**Reactions**	**ΔH (K.cal)**
I	$NaCl\ (s) + (aq) \rightarrow NaCl\ (aq)$	+1.2
II	$2C(s) + O_2(g) \rightarrow 2CO(g)$	–1.2
III	$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$	–177
IV	$NH_4Cl\ (s) \rightarrow NH_3(g) + HCl(g)$	+177

The reaction with maximum heat absorbed is

A I.
B II.
C III.
D IV.

xxv. The figure below shows exothermic reaction in which the energy is evolved from a system to the surrounding.

The change in enthalpy in the system is

A $\Delta H > 0$.
B $\Delta H < 0$.
C $\Delta H = 0$.
D $\Delta H \leq 0$.

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

i.	A sample of nitrogen gas has a volume of 25L under a pressure of 5 atm, the value of pressure would be ……atm when the volume is decreased to 5L.	
ii.	The lower alcohol dissolves in water due to the formation of …….. bonding.	
iii.	The product obtained by the combination of gangue with ……. is called slag.	
iv.	Upon analyzing common salt, it was found that salt lacked one of the halogens that is required for the normal metabolic function of the human body. The halogen missing in the salt is ……	
v.	An oxygen cylinder in the hospital holds 320g of oxygen. The number of moles of oxygen in the cylinder is …….	

c) **Write true or false for the following statements.** **[5]**

i. If you take an inflated football from a hot place to a cold place, its volume will increase.

ii. The boiling point of alcohol increases with an increase in molecular weight.

iii. In transition elements, the partially filled d-orbital electron(s) can be excited and moved between energy levels.

iv. The unbalanced chemical equation violates the law of conservation of mass.

v. For an endothermic reaction taking place at constant temperature and volume, ΔE will have a negative value.

i.	
ii.	
iii.	
iv.	
v.	

d) **Match each item under column A with the item in column B. Rewrite the correct pairs by writing alphabet against the number in the space provided.** **[5]**

Column A		Column B	
i.	Compression of gas molecules	a.	electronegative
ii.	One mole	b.	dehydrating agent
iii.	Sulphide ores	c.	6.023×10^{23} particles
iv.	Halogen	d.	roasting
v.	Sulphuric acid	e.	Boyles law
		f.	calcination

i.	
ii.	
iii.	
iv.	
v.	

SECTION B [60 MARKS]

ATTEMPT **ANY SIX** QUESTIONS

Question 2

a) Sonam has a tank that holds 0.5L of air at a temperature of 300K and a pressure of 880kPa. **[2]**

What volume would the air occupy if it were released into the atmosphere, where the pressure is 102kPa and the temperature is 327K?

b) A student designs an experiment to investigate the property of ethyl alcohol using acetic acid and conc. H_2SO_4.

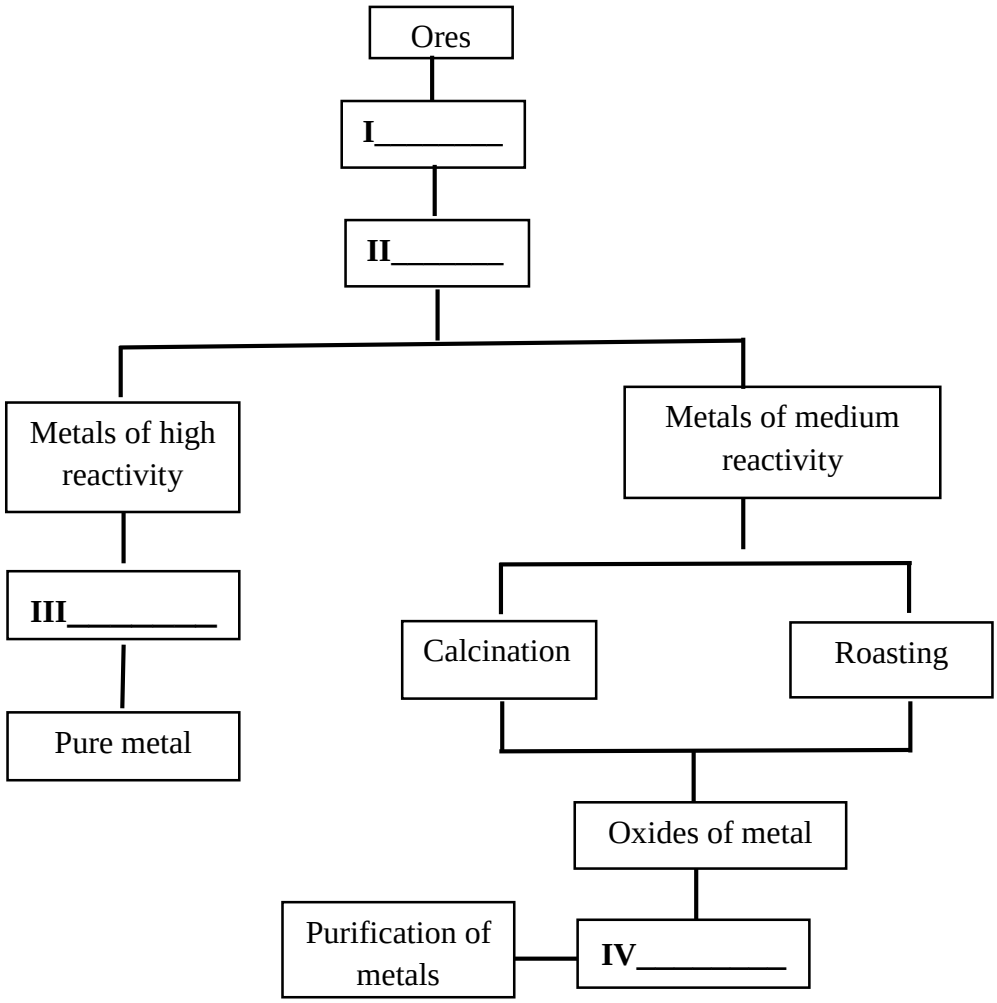
i. Complete the reaction. **[1]**

$C_2H_5OH + CH_3COOH$ (conc. H_2SO_4) → _____ + _____

ii. Name the products formed. **[1]**

iii. Name the derivative responsible for producing a fruity smell in the reaction. **[1]**

c) The flow chart below shows various steps involved in metal extraction.



i. Complete the missing steps involved in the above process. **[2]**

I	
II	
III	
IV	

ii. Which is the cheapest and most abundant reducing agent used to purify the oxides of metal? **[1]**

d) To sterilize contaminated water, chlorine is added. **[2]**
Mention **ONE** advantage and **ONE** disadvantage of chlorination.

Advantage	**Disadvantage**	

Question 3

a) Intense exercise leads to the formation of lactic acid that causes muscle fatigue. The table below shows the composition of lactic acid.

i. Complete the table and determine the empirical formula. **[2]**

Element	**Percentage by weight**	**Atomic ratio**	**Simplest ratio**	
Carbon	40%	3.33	_____	
Hydrogen	6.7%	6.7	_____	
Oxygen	53.3%	_____	1	
Empirical formula: _____				

ii. The molar mass of lactic acid is 90.08 g/mol. Determine its molecular formula. **[2]**

b) Calcium carbonate is heated at a very high temperature to decompose into calcium oxide and carbon dioxide. The chemical reaction is represented by the following equation.

$$\mathbf{CaCO_3\,(s) \rightarrow CaO(s) + CO_2(g)}$$

i. Is the above chemical equation balanced? Give **ONE** reason. **[1]**

ii. How many moles of carbon dioxide would be produced from one mole of calcium carbonate? **[1]**

iii. If 25 grams of calcium carbonate is heated, calculate the mass of calcium oxide produced. **[2]**

c) You are asked to design a canister for a beverage company. What are the properties of a canister you should consider? **[2]**

Question 4

a) Copper sulphate reacts with concentrated sodium hydroxide as shown in the equation.

$$\mathbf{CuSO_4(aq) + 2NaOH(aq) \rightarrow Cu(OH)_2(s) + Na_2SO_4(aq)}$$

i. Name the precipitate formed. **[1]**

ii. Which element is responsible for the formation of the coloured precipitate? **[1]**

iii. Why do you have be careful while handling concentrated sodium hydroxide? **[1]**

b) Airbags in cars reduce the severity of injuries during a head-on collision. The cushion is generated by rapidly inflating the airbag with N_2 gas. Airbag has sodium azide (NaN_3) that decomposes at high temperature into sodium metal and nitrogen gas, as shown in the equation.

$$\mathbf{2NaN_3 \rightarrow 2Na + 3N_2}$$

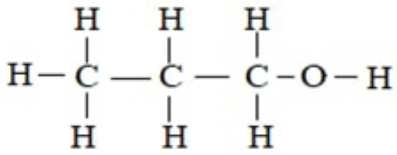
If 63 grams of nitrogen is required to inflate the airbag to its correct size, calculate the number of grams of NaN_3 used? **[3]**

c) Halogens are highly toxic and they corrode skin although some of their compounds are used as in toothpaste, table salt and antiseptic.

i. Why is iodine solution used during pre-operative skin preparation? **[1]**

ii. How does the fluoride in tooth-paste prevent cavities? **[1]**

d) The figure below shows the structure of an alcohol. Write its molecular formula and condensed formula.



i. Molecular formula **[1]**

ii. Condensed formula **[1]**

Question 5

a) A sample of an unknown gas having 60mL of volume is cooled from 27°C to 15°C.

i. Calculate the change in volume. **[3]**

ii. Define Charle's law. **[1]**

b) Give **ONE** reason for using ethanol in perfumes. **[1]**

c) *A flame test is carried out to identify an unknown metal ion. The heat of the flame excites the electrons of metal ions producing visible light.*

Using the following materials, write down the procedures to carry out a flame test. **[2]**

($CuCl_2$, candle, nichrome wire, spatula, watch glass, conc.HCl, matchbox)

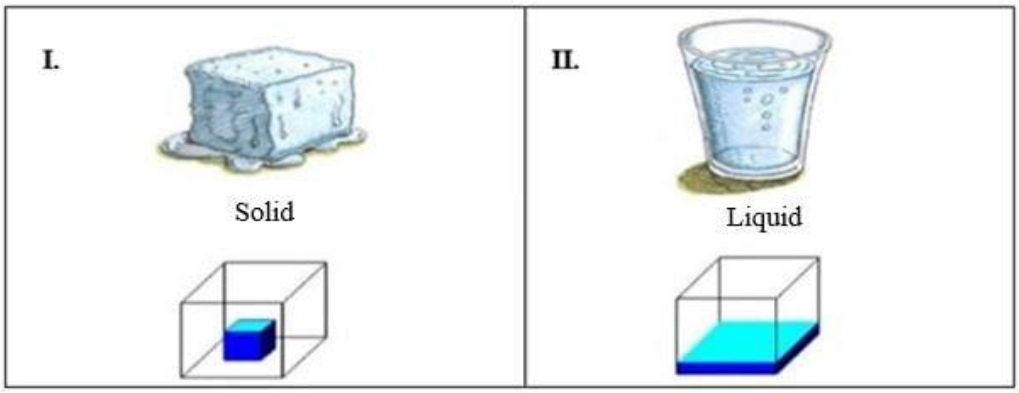
d) Arrange the elements Na, Cu, Mg and Zn in the decreasing order of their reactivity. **[1]**

e) Metals play an important role in the development of human society. It is used in making construction materials, electronics, decorative items, automobiles, medical equipment, etc. Metals are extracted from the Earth's crusts by mining. However, mining has negative impact on the environment.

Do you think metal extractions should continue despite having an adverse environmental impact? Support your answer. **[2]**

Question 6

a) Study the diagram of the states of water molecules as shown below and answer the questions that follow.



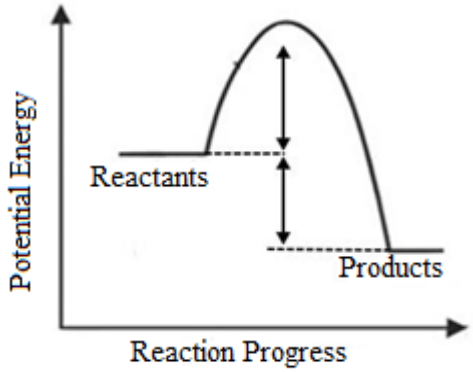
i. Which state of water has higher entropy? Why? **[2]**

ii. Predict the entropy of water vapour (gas). **[1]**

b) You are asked to make a pharmaceutical product having a mass of 18 grams using 11% C, 67% N, and 24% O. Calculate to determine the mass of carbon required. **[2]**

c) The fifth session of the third parliament of Bhutan (27 May – 30 June, 2021) decided to lift the ban on the issuance of new bar licenses. Do you think this is a good idea? Support your answer with relevant points. **[2]**

d) The graph below shows a thermochemical reaction. Answer the questions that follow.



i. Identify the type of thermochemical reaction. **[1]**

ii. How do you calculate enthalpy change in the chemical reaction? **[1]**

iii. Determine the sign for **[1]**

1.	enthalpy:	
2.	internal energy:	

Question 7

a) With reference to the transition elements, answer the following questions.

i. Do all transition metal compounds form coloured ions? Explain. **[1]**

ii. Mention any **TWO** uses of transition elements in the industry. **[1]**

iii. Give **TWO** metallic properties of copper. **[2]**

b) Dechen carried out an experiment to investigate a gas law using these materials: *beaker, ruler, thermometer, capillary tube and cooking oil*.
The observations were recorded as shown in the table below. Use the data to answer the following questions.

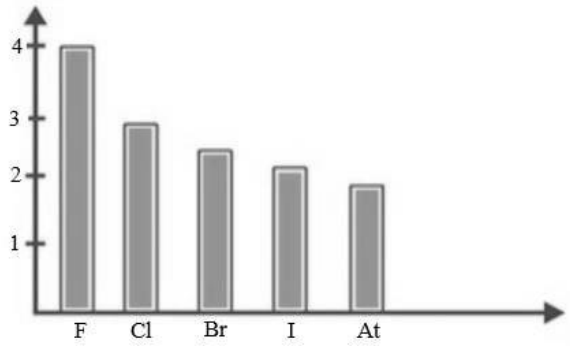
Trial	Volume (mL)	Temperature (°C)
1	50	25
2	100	50
3	150	75
4	200	100
5	250	125

i. Plot a volume–temperature graph. **[2]**

ii. What relationship can you draw from the graph? **[1]**

iii. What safety measures would you suggest while carrying out such an experiment? **[1]**

c) Study the electronegativity trend of halogens.



Electronegativity Trend – Down the Group

i. Which halogen forms the strongest polar covalent bonding? **[1]**

ii. Electronegativity value decreases down the group. Justify. **[1]**

Question 8

a) The number of atoms or ions immediately surrounding a central atom in a complex ion is called coordination number. What is the coordination number in $[Cu(NH_3)_4]^{2+}$? **[1]**

b) Inflating a balloon does not obey Boyle's law. Give a reason. **[1]**

c) Silver is extracted from argentite (Ag_2S) ore by Mac Arthur and Forrest's cyanide process. In the final step, impure silver is purified by electrolytic refining. The electrolyte used is silver nitrate solution.

Design a setup to purify the impure metal using the equipment given in the bracket. In your setup label cathode, anode, pure silver and impure silver. **[2]**
(thin sheet of pure silver, impure silver, silver nitrate, electrolytic cell, battery, wire, bulb)

d) Robert Boyle performed a series of experiments to examine the effect of pressure on the volume of a gas at a constant temperature. Derive Boyle's law. **[2]**

e) Refer the table on halogens and answer the questions that follow.

Element	Atomic number	Nuclear charge	Shielding electron	Effective nuclear charge
F	9	**A……**	2	+7
Br	35	+35	**B……**	+7

i. Complete the table. **[2]**

A:

B:

ii. Why does the effective nuclear charge remain relatively constant for each element down the group? **[1]**

iii. Which element has smaller atomic radius? **[1]**

Question 9

a) Alcohol consumption in Bhutan is significantly growing as more and more people are developing alcohol problems. According to the report, there is one alcohol outlet for every 177 Bhutanese. The high availability and lack of implementation of alcohol laws are leading to increasing alcohol problems among our people.

(Source: Alcohol availability and harm in Bhutan, Movendi international, Feb 25, 2020)

i. Design a poster to create an awareness campaign about alcohol consumption and its harmful effects. **[3]**
(Your poster should be relevant, impactful and understandable)

ii. Give **TWO** negative social impacts of drinking alcohol. **[1]**

b) All chemical reactions involve energy changes. The energy changes accompanying chemical reactions have numerous practical applications. Some of the chemical reactions are given below.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + Energy$$

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + Energy$$

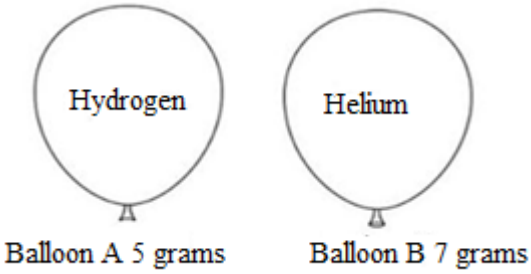
$$C_8H_{18} + \frac{25}{2}O_2 \rightarrow 8CO_2 + 9H_2O + Energy$$

Select the correct equation for the following uses.

i. Production of heat for cooking. **[1]**

ii. Combustion of fuel to run a car. **[1]**

c) Two balloons are filled with different gases. The mass of balloon A is 5 grams and the mass of balloon B is 7 grams.



i. How many moles of hydrogen are present in balloon A? **[1]**

ii. Determine which balloon contains a greater number of gas particles. **[2]**

iii. Calculate the volume of balloon B at STP. **[1]**