SECTION A [40 MARKS]

ANSWER **ALL** QUESTION

Question 1

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.** **[25]**

i. Which of the following halogen is radioactive in nature?

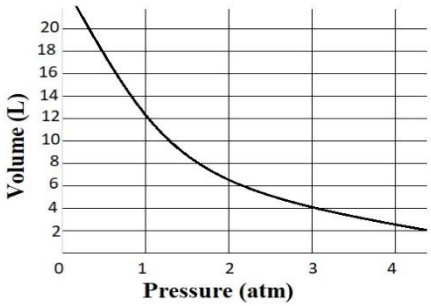
A Fluorine
B Chlorine
C Astatine
D Iodine

ii. When the impure metal is placed on the sloping hearth of the furnace and heated moderately, dross remains in the hearth and the metal melts and flows down.

The process outlined in the above statement is

A distillation.
B reduction.
C liquation.
D oxidative refining.

iii. The diagram given below shows an initial volume of 12 litres at a pressure of 1 atm. What will be the new volume when the pressure is increased to 3 atm?



A 2 L
B 4 L
C 6 L
D 8 L

iv. What is the coordination number of the given complex compound $[Cu(NH_3)_4]^{2+}$?

A 3
B 4
C 6
D 12

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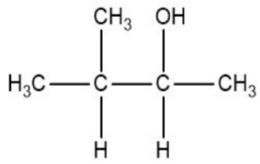
v. The correct IUPAC name of the given structural formula of alcohol is



A 2-methylbutan -2-ol.
B 3-methylbutan -2-ol.
C 2-methylbutan -3-ol.
D 2,2-dimethylbutan -2-ol.

vi. A novice pharmacist formulated an antacid tablet [$Mg(OH)_2$] to treat acute stomach ailments. Find the percentage composition of Mg in it.

A 41.17%
B 41. 27%
C 41. 37%
D 41. 47%

vii. What is the correct formula to find the relationship between the vapour density and molecular mass?

A Vapour density = 2 x Molecular mass
B Vapour density = $\frac{\textbf{Molecular mass}}{\textbf{2}}$
C Molecular mass = (vapour density)1/2
D Vapour density = (Molecular mass)2

viii. Geyzing investigated Gay Lussac law by performing an experiment. Table given below shows the record of the experiment.

Experiment	Temperature (K)	Pressure (mmHg)
Round 1	297.2	606.2
Round 2	307.2	626.4
Round 3	317.2	646.6
Round 4	327.2	646.5
Round 5	337.2	707.1

An error in the finding was observed in which round?

A 4
B 3
C 2
D 1

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ix. Ethanol supplied to hardware shops is rendered unfit for consumption. Which three mixtures of chemical substances makes it non consumable?

A methanol + pyridine + $MgSO_4$
B methanol + pyridine + $CuSO_4$
C methanol + pyridine + $FeSO_4$
D methanol + pyridine + H_2SO_4

x. While digging in the backyard, you find chunks of impure copper, potassium, silver and sodium metals. Choose the appropriate metals which will undergo purification by electrolytic refining method.

A Cu and K
B Ag and Na
C Cu and Na
D Cu and Ag

xi. From the given balanced redox reaction, identify the reducing agent.

$$Cl_2\,(aq) + 2Br^-\,(aq) \longrightarrow 2Cl^-\,(aq) + Br_2\,(aq)$$

A Cl_2
B Br^-
C Cl^-
D Br_2

xii. Most of the transition elements have variable oxidation states. Although zinc is a member of the transition elements, it does not exhibit variable oxidation states. This is because

A d orbital is half filled.
B p orbitals is completely filled.
C d orbitals is completely filled.
D d orbital is incompletely filled.

xiii. The molecular formula of a compound is $C_6H_{12}O_6$ and its empirical formula mass is 30g. The empirical formula of the compound is

A $C_2H_4O_2$.
B CH_2O.
C $C_{12}H_{22}O_{11}$.
D $C_9H_{18}O_9$.

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xiv. Dew Shanja, who lives near a snow-capped mountain experienced freezing temperatures as the snow melted. Identify the thermochemical reaction.

A redox reaction

B exothermic reaction

C endothermic reaction

D biochemical reactions

xv. What is the best way to characterize inverse relationships between variables?

A one variable remains the same, the other variable changes
B one variable increases, the other variable undergoes a random change
C one variable increases, the other variable decreases proportionally
D one variable decreases, the other variable also decreases at the same rate

xvi. The specific number of particles present in one mole of any substance at STP is

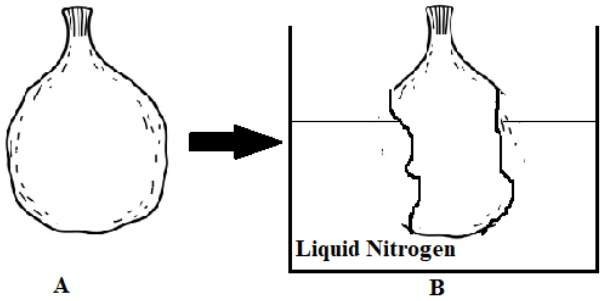
A 6.023×10^{23}.
B 60.23×10^{23}.
C 602.3×10^{23}.
D 6023×10^{23}.

xvii. Nano science an emerging technology deals with materials whose size ranges from

A 1 – 10 nm.
B 1 – 100 nm.
C 100 – 1000 nm.
D 200 – 2000 nm.

xviii. During an experiment, Phurba Thinley was asked to place a balloon in a container containing liquid nitrogen at -196.0°C, as shown in the figure. The balloon deflates. Which gas law explains this?

A Charle's law
B Boyle's law
C Avogadros' law
D Gay Lussac's law



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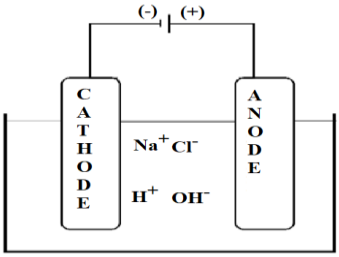
xix. In your chemistry lab there is a shortage of ethanol. How can you prepare fresh alcohol?

A Mix cold water with glucose and yeast
B Mix warm water with maltose and yeast
C Mix warm water with glucose and yeast
D Mix warm water with starch and yeast

xx. The diagram given below shows the electrolysis of a concentrated sodium chloride solution. Which ion will get discharged at the cathode?



A Na^+
B H^+
C Cl^-
D OH^-

xxi. Choose the best conditions for high yields of ammonia.

$$N_{2\,(g)} + 3H_{2\,(g)} \rightleftharpoons 2NH_{3\,(g)}$$

A Fe, decrease in temperature and increase in pressure
B Fe, increase in temperature and decrease in pressure
C Ni, decrease in temperature and increase in pressure
D Ni, increase in temperature and decrease in pressure

xxii. One mole of any substance occupies 22400 ml volume at STP. What will be the volume occupied by half mole of the given substance at STP?

A 1400 ml
B 2800 ml
C 5600 ml
D 11200 ml

xxiii. Which halogen would you suggest to purify a swimming pool?

A Iodine
B Astatine
C Bromine
D Fluorine

xxiv. The expected electronic configuration of chromium is $1s^2\ 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4$ while the observed electronic configuration is $1s^2\ 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$. The reason for this is because

A d orbitals should be half filled and stable.
B p orbitals should be completely filled and stable.
C d orbital should be completely filled and stable.
D d orbital should be incompletely filled and stable.

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xxv. From the given general equation formula, A+B $\longrightarrow$ AB, identify the type of chemical reaction.

A combustion reaction
B combination reaction
C displacement reaction
D decomposition reaction

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

i. The thermal scanner device reads 309.5 K and the same reading in degree celsius is _____

ii. From the list of specified alcohol (butanol, propanol, pentanol), _____ is readily soluble in water.

iii. _____ is one of the halogens used as an antiseptic in healing wounds.

iv. The simplest formula of a compound which gives the simple whole number ratio of various elements is _____.

v. In a reaction, if $H_R < H_p$, then the value of ΔH will be _____.

c) Write **TRUE** or **FALSE** for the following statements. **[5]**

i.	During the distillation of a homogenous mixture of ethanol and water, ethanol is collected before water.		
ii.	The element X with atomic number 17 belongs to group 15 and 3rd period.		
iii.	The electronic configuration of Fe as per s, p, d, f notation is 1s2 2s22p63s23p64s23d6.		
iv.	Chlorine is composed of two isotopes in the ratio of 75% chlorine-35 and 25% chlorine- 37. The RAM of chlorine is 36.5.		
v.	At Tala Dam, turbines rotate with high rotations per minute (RPM) during peak monsoon converting kinetic energy into electrical energy in the process. The function of Tala Dam does not obey the law of conservation of energy.		

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d) Match each item under column A with the most appropriate item in column B. Write the correct alphabet in the space provided under the 'answer 'column. **[5]**

Answer	Column A	Column B
i.	i. Pumping of bicycle tyre	**a)** OH
ii.	ii. Increase in random movement of particles	**b)** Cu
iii. ……..	iii. Not a transition element	**c)** Boyle's law
iv. ……..	iv. Functional group of alcohol	**d)** entropy
v. ……	v. Functional group of aldehyde	**e)** Charle's law
		f) Na
		g) CHO

SECTION B [60 MARKS]

ATTEMPT **ANY SIX** QUESTIONS

Question 2

a) The steering wheel of a vehicle has an airbag containing 260g of NaN_3 (sodium azide) and the temperature inside the airbag is 40°C with normal air pressure of 1 atm. Calculate the volume of the airbag when 2 moles of gas is released from it when it gets deployed. **[2]**

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b) If the molecular formula of a compound is Na_2O_2, compute the empirical formula, if the value of n is 2. **[2]**

c) The MoEA approved 1,282 restaurant owners to sell liquor in the past 10 days since the Govt. decided to allow restaurants to serve alcohol. *(Source: Kuensel June 11, 2022).* As a healthcare worker, how can you encourage people to quit alcohol? **[2]**

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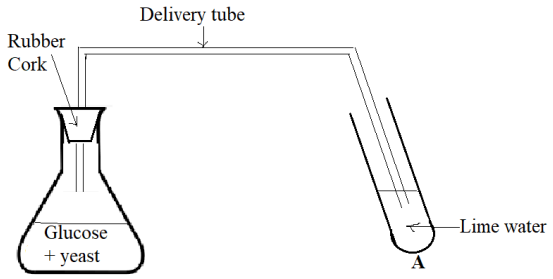
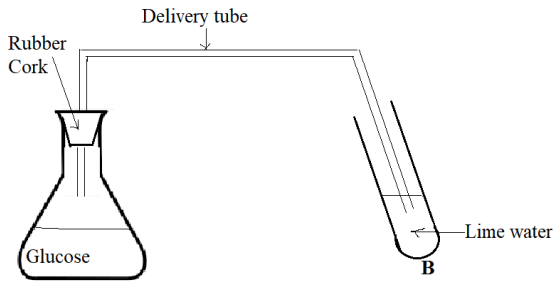
d) A student designed an experiment to investigate the production of carbon dioxide as shown in the figure given below.

Set up I	Set up II
	

i. In which test tube is carbon dioxide produced? **[1]**

ii. How can the student confirm the presence of carbon dioxide? **[1]**

e)

i. In the contact process, how can you increase the production of sulphur trioxide in the given reaction. **[1]**

$2SO_2 + O_2 \rightleftharpoons 2SO_3$

ii. You are asked to prepare hydrochloric acid by adding hydrogen to chlorine in three different locations: dark room, diffused sunlight and direct sunlight. In which location would you prefer to prepare the acid and why? **[1]**

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Question 3

a) At 100^0C and 0.98 atm, a balloon holding 100 L is launched at Paro. If the hot air balloon has the final volume of 154L at -10°C, how much pressure will the balloon experience as it passes over Jomolhari? **[2]**

b) What is the GMM of H_2SO_4 ? **[1]**

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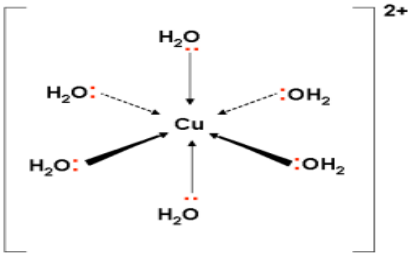
c) Calculate the effective nuclear charge experienced by the electrons present in the L shell of calcium atom. **[1]**

d)

i. Based on the given complex ion, answer the following questions.



1) Identify the central metal atom and chemical bond. **[1]**

2) People have ventured into space economy and companies like SpaceX and Blue Origin Amazon have planned to build a lunar base on the moon by 2023 to extract metals such as titanium and precious metals. Do you think it would be wise to extract metals from the moon? Why? **[1]**

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ii. As a metallurgist in Druk Wang Alloys Limited at Pasakha, Bhutan. What separation method would you use to separate iron ore (Fe_3O_4) mixed with soil and pebbles? Why did you choose this method? **[2]**

e)

i. All the transition elements of 3d series are coloured except zinc. Explain. **[1]**

ii. Why does manganese exhibit the highest variable oxidation state among all the transition elements in 3d series? **[1]**

Question 4

a) Aum Sangmo from Trashigang wants to bleach the threads to weave a kira for her daughter.

i. Which halogen would you choose? **[1]**

ii. Write the balanced chemical equation to show the mechanism of bleaching action. **[2]**

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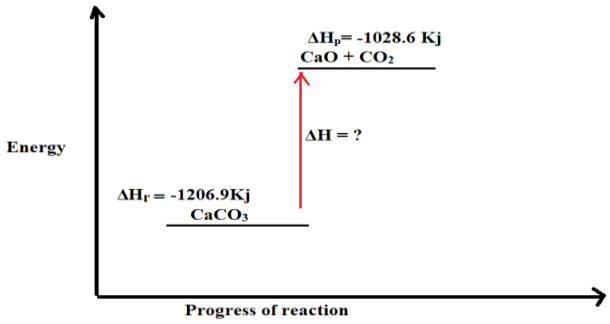
b) A Chemistry lab assistant conducted an experiment to verify a gas law. After performing the experiment the following sets of data were obtained. Based on the data given, answer the following questions:

Moles of gas	0.5	1	1.5	2	2.5
Volume (L)	2	4	6	8	10

iii. Plot a graph of moles and volume data. Place mole (n) on x -axis and volume (L) on the y-axis. **[1]**

iv. Which gas law does the graph obey? **[1]**

c) As a NASA chemical engineer, your role is to produce carbon dioxide by decomposing of lime stone ($CaCO_3$) available on the surface of Mars. Study the given diagram below.



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i. Calculate the change in enthalpy of the decomposition reaction. **[1]**

ii. Identify the type of reaction. **[1]**

d) Write the molecular formula of an alcohol having carbon number 4 and 5. **[2]**

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Question 5

a)

i. If the pressure of a gas is halved and the volume of the gas doubled, how will the volume change? **[1]**

ii. If one mole of a substance contains Avogadro's number 6.023×10^{23} particles, calculate the number of particles present in half mole of the substance? **[1]**

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b) Due to high energy demand, Bhutan has installed 6087 biogas plants in all 20 Dzongkhags in 2021. One of the main components of biogas produced from cow dung is methane. Describe how energy is extracted from methane using a balanced chemical reaction. **[2]**

c) Copper extracted from copper pyrites ($CuFeS_2$) ore is impure and it is purified by electrolytic refining. The electrolyte used is copper sulphate solution.

i. Design a set up to purify impure copper metal using the equipment given in the brackets. In your set up, label pure copper, impure copper, copper sulphate and anode mud. **[2]**
(Thin sheet of pure copper, impure copper, copper sulphate, electrolytic cell)

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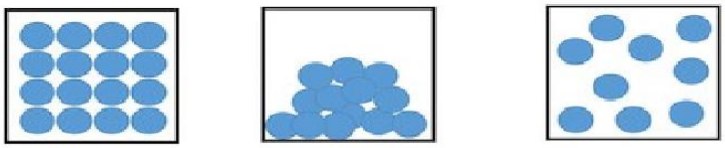
ii. What will happen if a copper spoon is used to stir zinc sulphate solution? **[1]**

d) Study the diagram given below and answer the following questions.



i. Which state of matter has the lowest entropy? **[1]**

ii. Arrange the states of matter in increasing order of entropy. **[1]**

e) What is a functional group? **[1]**

Question 6

a) A tyre of a truck containing 30 moles of air and occupying a volume of 60L loses half of its volume due to a puncture. Considering that pressure and temperature remain constant, what would be the amount of air left in the deflated tyre? **[2]**

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b) In the given diagram, set up I and set up II has equal number of moles of hydrogen and water. Explain which set up has the lowest number of particles? **[1]**

H_2 molecule **0.5 moles**	**H_2O molecule** **0.5 moles**
Set up I	**Set up II**

c) Sonam conducted an experiment by mixing iodine with aqueous sodium chloride solution. Is the reaction given below possible? Justify. **[2]**

$$I_{2(s)} + 2NaCl \longrightarrow Cl_{2\,(g)} + 2NaI_{(S)}$$

d) Study the table given below and fill in the blanks with the correct answers at STP. **[2]**

Elements → / **Compound variables** ↓	**Hydrogen**	**Nitrogen**	**Sulphur dioxide**
Volume	22.4 L	**i. ……**	22400 ml
Pressure	**ii. ……..**	1 atm	**iii.** .....
Molecular mass	2	28	**iv.** .....

e)

i. Jet Propulsion laboratory built ultra-light ingenuity helicopter using the metals aluminium and titanium. Give **TWO** appropriate reasons for using aluminium. **[2]**

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ii. Draw the atomic structure of fluorine. **[1]**

Question 7

a) Before a plane takes off, a flight attendant's tego fits her perfectly. But as the plane glides to a higher altitude, her tego gets tighter on her body. Why? Explain using the gas laws. **[2]**

b) The table below shows the composition of aspirin.

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

Element	Percentage Composition	Atomic weight	Relative no. of atoms	Simplest ratio
C	60%	12	$\frac{60}{12}=5$	2
H	4.5%	1	……	……..
O	35.5%	16	$\frac{35.5}{16}=2.21$	……..
Empirical formula: ……..				

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ii. The molecular mass of aspirin is 84 g/mol. Determine its molecular formula. **[2]**

c) Draw the formation of the atomic structure of fluorine molecule and identify the type of chemical bond present in the molecule. **[2]**

d) A breathalyzer test indicates that a person has consumed liquor.

i. How will you confirm the test is positive? **[1]**

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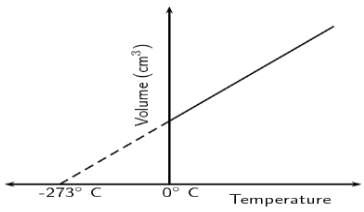
ii. Name the reaction which takes place in the breathalyzer and write the molecular formula of ethanol. **[1]**

Question 8

a) The figure given below demonstrates the behaviour of a certain gas. Study the figure and answer the following questions.



i. State the law. **[1]**

ii. Does the volume of the gas reduce to half the original volume, if the temperature is reduced from 50^0 C to 25^0 C? Justify your answer with a reason. **[1]**

b) A new recipe for a fruit cocktail contains mostly carbohydrates ($C_6H_{12}O_6$). Calculate the mass percentage composition of carbon and oxygen. **[2]**

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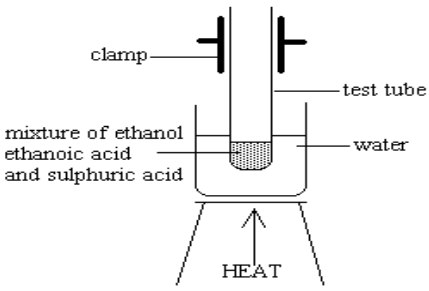
c) The diagram given below represents an experimental set up for an esterification reaction. What is the main product formed during the reaction and give any **ONE** of its application. **[1]**



d)

i. During the manufacturing process of ferro silicon alloys, large amount of polluted gases are released into the atmosphere. Do you think the production of ferro silicon should continue to support the economy of the country despite having such impacts on health and environment? Support your answer. **[2]**

ii. In Aufbau's principle of order of filling orbitals, why does 3s orbital get filled by electrons before 3p orbital? **[1]**

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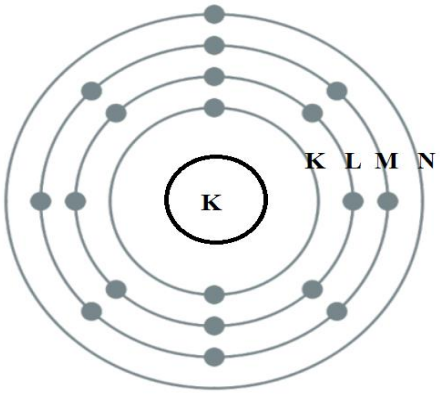
e) From the given atomic structure of potassium, identify the sub shells or orbitals present in its L and M shell? **[2]**



Question 9

a) Define electro chemical series of metals. **[1]**

b) Evaluate the number of water molecules in 48g of water. **[1]**

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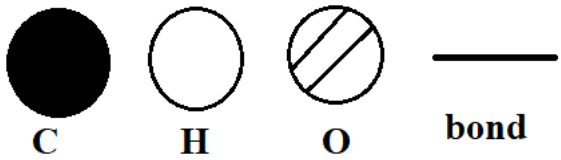
c) Create a 2D model of monohydric alcohol methanol using the given shapes to represent elements. **[2]**



d) Write **ONE** difference as specified in the bracket ( ) between the following pairs:

i. Paramagnetic and diamagnetic substance **(Magnetic property)** **[1]**

Paramagnetic Substance	**Diamagnetic Substance**	

ii. P orbital and d orbital **(electron accommodation capacity)** **[1]**

P orbital	**D orbital**	

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e)

i. Your chemistry teacher has provided two salts A and B. 5 mL of sodium hydroxide was added to the solutions of A and B. A solution gave a rich red precipitate and B changed to gelatinous white precipitate. Identify the two salts and write their chemical formula. **[2]**

ii. A presentation on exothermic reactions is given in your chemistry class. How would you explain breathing as an exothermic reaction to your classmates? **[1]**

iii. Write the difference between exothermic and endothermic reaction with respect to change in internal energy (ΔE) **[1]**

Exothermic reaction	Endothermic reaction	

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