Chemistry Recapture-2025

Paper 02

Instructions:

- *This paper consists of **04** pages.*
- *Answer **all** the questions.*
- ***Use of calculators is not allowed.***
- *Write your **Index Number** in the space provided in the answer sheet.*

Index Number:

Universal gas constant R= 8.314 J K^{-1} mol^{-1}

Velocity of light C = 3 x 10^{8} m s^{-1}

Planck's constant h = 6.626 x 10^{-34} J s

Baltzmann constant k_B = 1.38 x 10^{-23} J K^{-1}

Avogadro constant N_A = 6.022 x 10^{23} mol^{-1}

PART A – STRUCTURED ESSAY

1.

a.

i. Write down the three main assumptions of the molecular kinetic theory of an ideal gas.

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ii. Write the equation of molecular kinetic theory and identify the terms.

iii. Using both the above equation and the equation in ideal gas law, state the equation for the root mean square speed of an ideal gas.

iv. Vessel A contains Helium gas at 227 °C. Vessel B contains Oxygen gas at 127 °C. What is the ratio of the root mean square speed of the gases contained in containers A and B? (M_{He} = 4.0 g mol^{-1} and M_{O2}= 32.0 g mol^{-1})

b.

i. Using both the equation in a (ii) and the equation in ideal gas law, state the equation for the kinetic energy of an ideal gas (per molecule). Boltzmann constant $k_B = R/N_A$

ii. At what temperature will the root mean square speed of an ideal gas be sufficient to escape from the earth? (Escape speed of earth = 11.2 km s^{-1} and mass of ideal gas = 6 x 10^{-26} kg).

c. If Z is a compressibility factor, write the van der Waals equation at low pressure using Z.

PART B- ESSAY

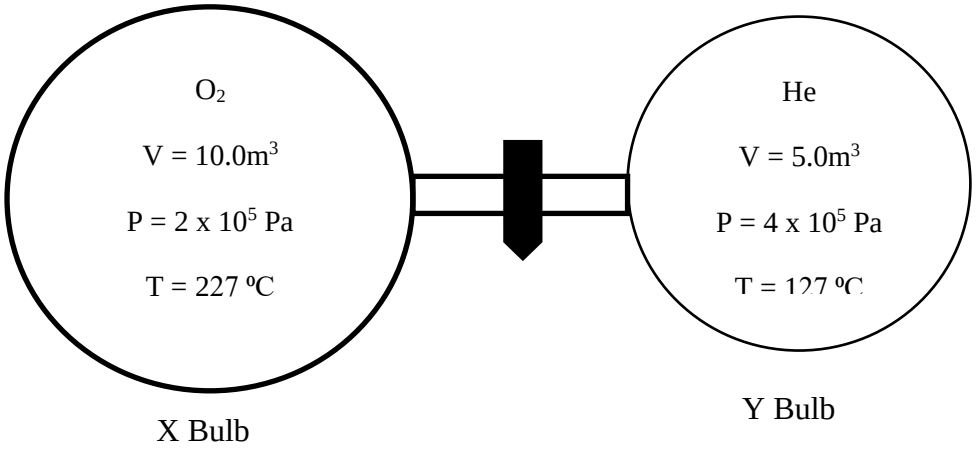
01)

A.

I. Write down the ideal gas equation and define the terms.

II. Derive Dalton's equation for partial pressure from the ideal gas equation. (Hint: Consider mixture of gases A and B in a volume V at constant temperature.)

B. The two bulbs X and Y are connected by a valve, and initially the valve is closed. Bulb X is filled with only oxygen gas, and bulb Y is filled with only He gas. Each gas is under the conditions shown in the diagram below.



By opening the valve, the gases contained in the two bulbs are allowed to mix freely and completely with each other. However, each bulb and the temperature of each bulb are maintained at their initial value. Assuming that oxygen and He gases behave as ideal gases and that the volume of the valve is negligible, calculate the following in **SI units**.

I. The number of moles of oxygen gas initially contained in the **X** bulb.

II. The number of moles of He gas initially contained in the **Y** bulb.

III. The total amount of gas in both bulbs.

IV. Final pressure of the gas mixture in the **Y** bulb.

V. The partial pressure of He gas in the final gas mixture in the **X** bulb.

C. The potassium dichromate solid undergoes complete thermal decomposition as follows:

$$4K_2Cr_2O_7(s) \longrightarrow 4K_2CrO_4 + 2Cr_2O_3(s) + 3O_2(g)$$

I. You are provided with a solid of pure potassium dichromate. Explain clearly how you would experimentally determine the molar volume of oxygen gas at standard temperature and pressure using this compound. (O=16)

II. Explain why the above experimentally obtained value differs from the expected value.