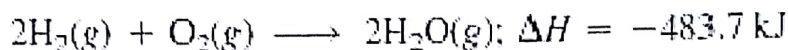


Model answer of midterm exam of General Chemistry 13-Nov-2017

Question 1 (10 marks, 2 marks for each point)

Consider the reaction of hydrogen and oxygen to produce water. If the product is water vapor, 2 mol of H<sub>2</sub> burn to release 483.7 kJ of heat.



1. Is the reaction spontaneous or not. Explain your answer. What is the effect of temperature on the reaction spontaneously?
2. Calculate internal energy change ( $\Delta E$ ) at 25 °C.
3. Calculate the density (in g/L) and average speed (in m/s) of O<sub>2</sub>(g) at STP?
4. What are the relative rates of diffusion of O<sub>2</sub>(g) to H<sub>2</sub>(g)?
5. Predict the value of work done if O<sub>2</sub>(g) expanded against a vacuum.? Give reason of your answer?

Answer

1. Since the sign  $\Delta S$  of the reaction is -ve because the number of moles of products is less than reactants i.e. more ordered. The reaction is spontaneous at low temperature because both the sign of  $\Delta H$  and  $\Delta S$  is -ve.
2. Since  $\Delta n$  of reaction = 2-3 = -1

$$\Delta E = \Delta H - \Delta nRT$$

$$\Delta E = -483.7 - (-1)(0.008314)(298) = -481.222428 \text{ kJ/mole}$$

3. Density of O<sub>2</sub> gas at STP =  $PM/RT = 1 \times 32/0.082(273) = 1.429 \text{ g/L}$

$$\text{Average speed of O}_2 \text{ gas at STP} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.314 \times 273}{0.032}} = 461.28 \text{ m/s}$$

4. Since molecular weight of O<sub>2</sub> gas = 32 g/mole and molecular weight of H<sub>2</sub> gas = 2 g/mole. So the slower gas must be O<sub>2</sub> gas.

Suppose the rate of diffusion of O<sub>2</sub> gas = 1

$$\frac{\text{Rate of H}_2 \text{ diffusion}}{\text{Rate of O}_2 \text{ diffusion}} = \sqrt{\frac{\text{molecular mass of O}_2}{\text{Molecular mass of H}_2}} = \sqrt{\frac{32}{2}} = 4$$

The rate of diffusion of O<sub>2</sub>: H<sub>2</sub> is 1:4

5. The work done equal zero because the pressure in this case = zero and according to law  $W = -P\Delta V$  when  $p = \text{zero}$  the work must be zero.

Question 2 (5 marks)

- a) Write a mathematical expression of the following [3 marks, 1 mark for each point]
- First law of thermodynamic
  - Second law of thermodynamic
  - (PVT) relationship of real gases.
- b) Classify the following properties as intensive or extensive properties. Explain your answer

Temperature-velocity-pressure-surface area-viscosity [2 marks]

Answer

a)

- $\Delta E_{\text{universe}} = \text{zero, or } \Delta E = Q + W$
- $\Delta S_{\text{universe}} > 0$

Correction for intermolecular attractions.      Correction for molecular volume.

van der Waals equation:  $\left( P + \frac{an^2}{V^2} \right) (V - nb) = nRT$

or  $P = \frac{nRT}{V - nb} - \frac{an^2}{V^2}$

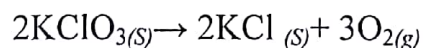
III.

- b) Temperature-velocity-pressure and viscosity are intensive properties because it does not depend on mass of matter but depend on type of matter.

Surface area is extensive property because it depends on mass of matter.

Question 3 (5 marks)

A sample of solid potassium chlorate ( $\text{KClO}_3$ ) was heated in a test tube and decomposed by the following reaction



The oxygen produced was collected at  $22^\circ\text{C}$  and a pressure of 733 torr. The volume of the gas collected was 650 mL, *Calculate* the mass of  $\text{KClO}_3$  (*Mol. Wt.* = 122.6) in the sample that was decomposed. **What** do you expect of the value of volume gas if the pressure of gas changed to 850 torr at  $15^\circ\text{C}$ .

Answer

*Model answer of midterm exam of General Chemistry 13-Nov-2017*

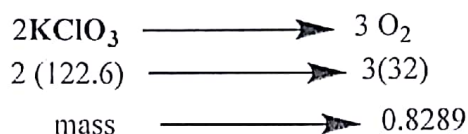
P of O<sub>2</sub> gas = 733/760 = 0.964 atm, V = 0.65L and T = 22+273 = 295 °K

Since  $PV = nRT = \frac{m}{M}RT$

So  $0.964 \times 0.65 = \frac{m}{32} \times 0.082 \times 295$

Mass of O<sub>2</sub> = 0.8289 g

Since



Mass of KClO<sub>3</sub> = 0.8289(2)(122.6)/3(32) = 2.117 g

- In case of changing pressure and temperature

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

- Since P<sub>1</sub> 0.964 atm, V = 0.65 L and T = 295 °K
- P<sub>2</sub> = 850 torr = 850/760 = 1.118 atm, V<sub>2</sub>=? and T = 15+273 = 288 °K
- So  $\frac{0.964 \times 0.65}{295} = \frac{1.118 \times V_2}{288}$

Volume = 0.547 L

*With my best wishes*

*Associate Professor Dr: Khaled Samir Mohammed*