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_2 burn to release 483.7 kJ of heat.

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g);\ \Delta H = -483.7\ kJ$$

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 (ΔE) at 25 °C.
3. Calculate the density (in g/L) and average speed (in m/s) of $O_2(g)$ at STP?
4. What are the relative rates of diffusion of $O_2(g)$ to $H_2(g)$?
5. Predict the value of work done if $O_2(g)$ expanded against a vacuum.? Give reason of your answer?

Answer

1. Since the sign ΔS 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 ΔH *and* ΔS is –ve.
2. Since Δn of reaction = 2-3 =-1

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

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

3. Density of O_2 gas at STP = PM/RT = 1 x 32/0.082(273) = 1.429 g/L

$$\text{Average speed of } O_2 \text{ gas at STP} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3x\ 8.314\ x\ 273}{0.032}} = 461.28\ m/s$$

4. Since molecular weight of O_2 gas =32 g/mole and molecular weight of H_2 gas =2 g/mole. So the slower gas must be O_2 gas.

Suppose the rate of diffusion of O_2 gas = 1

$$\frac{Rate\ of\ H2\ diffusion}{Rate\ of\ O2\ diffusion} = \sqrt{\frac{molecular\ mass\ of\ O2}{Molecular\ mass\ of\ H2}} = \sqrt{\frac{32}{2}} = 4$$

The rate of diffusion of O_2: H_2 is 1:4

5. **The work done equal zero because the pressure in this case = zero and according to law W=-PΔv when p= 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]

I. First law of thermodynamic

II. Second law of thermodynamic

III. (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)

I. $\Delta E_{universe} = \text{zero, or } \Delta E = Q + W$

II. $\Delta S_{universe} > 0$

Correction for intermolecular attractions. Correction for molecular volume.

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

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

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 ($KClO_3$) was heated in a test tube and decomposed by the following reaction

$$2KClO_{3(S)} \rightarrow 2KCl_{(S)} + 3O_{2(g)}$$

The oxygen produced was collected at 22°C and a pressure of 733 torr. The volume of the gas collected was 650 mL, ***Calculate*** the mass of $KClO_3$(*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 °C.

Answer

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P of O_2 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 X 0.65 = $\frac{m}{32}$X 0.082 X 295

Mass of O_2= 0.8289 g

Since

$$2KClO_3 \longrightarrow 3\,O_2$$
$$2\,(122.6) \longrightarrow 3(32)$$
$$\text{mass} \longrightarrow 0.8289$$

Mass of $KClO_3$ = 0.8289(2)(122.6)/3(32) = 2.117 g

- In case of changing pressure and temperature

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

- Since P1 0.964 atm, V = 0.65 L and T = 295 °K
- P_2 = 850 torr = 850/760 = 1.118 atm, V_2 =? and T = 15+273 = 288 °K
- So $\frac{0.964\ x\ 0.65}{295} = \frac{1.118\ x\ V2}{288}$

Volume = 0.547 L

With my best wishes

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