

CHM2132 Midterm 1
Friday October 9th, 2015

Name: _____

Student #: _____

This is a closed book exam with no notes allowed.

Calculators are permitted.

Show all your work.

Remember to include units in all your calculations.

Marks will be deducted if units are not shown in your final answer.

You will find the equations, data and constants on the last page. You may rip this page off of the midterm and use it to cover your work during the test.

Q1: _____/6

Q2: _____/11

Q3: _____/9

Q4: _____/14

Total = _____/40

1. The following statements are **FALSE**. **Choose 3 of the 4 statements below** and:

(i) Change the sentence so that it becomes a correct statement.

(ii) In one sentence explain why the statement was incorrect. In some cases you might use an equation to help your explanation. (6 marks)

a) To calculate the work done on a warm ideal gas trapped in a balloon after it is put in the fridge, it is

possible to use $w = -nRT \ln\left(\frac{V_2}{V_1}\right)$ if the volume change is very slow.

b) The standard state of H₂O is solid.

c) No heat is absorbed by air trapped in a sealed bottle when the bottle is opened if the temperature of the air outside the room is the same as the temperature of the air in the bottle.

d) The partial derivative $\left(\frac{\partial V}{\partial T}\right)_{n,p}$ can be used to calculate the change in volume for an ideal gas that is compressed in a thermally insulated balloon.

2. A 1.60 mol sample of an ideal gas with $C_{V,m} = 5/2 R$, at 2.82 bar, 340.0 K is expanded adiabatically against an external pressure of 0.230 bar until the final pressure is 0.250 bar.

a) What is the final temperature of this gas? (4 marks)

b) What is the total work done in this process? (3 marks)

c) Draw a reversible adiabatic expansion on a pressure-volume diagram. Be sure to label the axes with p and V, show isotherm(s) and label initial and final states. (4 marks)

3. A mixture of H_2 and NH_3 in a 500.0 mL vessel at 0.00°C has a pressure of 1.00 atm. The mixture is cooled to 77.0 K, which causes the ammonia to freeze. The remaining gas is removed from the vessel, which is then warmed up to 25.0°C to give a pressure of 0.344 atm.

a) What is the mole fraction of NH_3 in the original mixture? (4 marks)

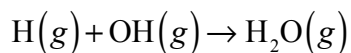
b) Is the internal energy of NH_3 at the end of the process higher, lower, or equal to, its internal energy at the end of the process? Briefly explain your answer. (2 marks)

c) If H_2 and NH_3 undergo attractive interactions, would the original gas mixture release heat if it was allowed to undergo an isothermal expansion into a completely empty 1 L container? Why or why not? (3 marks)

4.

ΔH_R° (kJ mol ⁻¹)		$C_{p,m}$ (J mol ⁻¹ K ⁻¹)	
$\text{H}_2(g) + \frac{1}{2}\text{O}_2(g) \rightarrow \text{H}_2\text{O}(g)$	-242	$\text{H}_2(g)$	28.8
			29.4
$\frac{1}{2}\text{H}_2(g) + \frac{1}{2}\text{O}_2(g) \rightarrow \text{OH}(g)$	40.0	$\text{O}_2(g)$	$32.83 - 0.00363 \frac{T}{K}$
$\text{H}_2(g) \rightarrow 2\text{H}(g)$	426	$\text{H}(g)$	20.8
$\text{O}_2(g) \rightarrow 2\text{O}(g)$	498	$\text{O}(g)$	21.9
		$\text{OH}(g)$	29.9
		$\text{H}_2\text{O}(g)$	33.6

Use the data in the table (all at 298.15 K) to answer the following questions about this reaction:



- a) Calculate ΔH_R° at 298.15 K. You must show your work using balanced chemical equations for full marks. (3 marks)

- b) Based on your answer in a), is this reaction endothermic or exothermic. (1 mark)

c) Calculate ΔU_R° at 298.15 K. (3 marks)

d) Calculate ΔH_R° at 400.15 K. (3 marks)

e) Calculate the heat required to raise the temperature of $\text{O}_2(g)$ from 298.15 K to 400.15 K under standard conditions. (4 marks)

Constants and Data

$$\begin{aligned}
 R &= 8.314 \text{ J K}^{-1} \text{ mol}^{-1} = 0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1} = 0.08314 \text{ L bar mol}^{-1} \text{ K}^{-1} \\
 1 \text{ L} &= 10^{-3} \text{ m}^3 & 1 \text{ kJ} &= 1000 \text{ J} & 1 \text{ atm} &= 101325 \text{ Pa} \\
 1 \text{ bar} &= 10^5 \text{ Pa} & 1 \text{ L atm} &= 101.325 \text{ J} & 1 \text{ J} &= 1 \text{ kg m}^2 \text{ s}^{-2} & 1 \text{ Pa} &= 1 \text{ kg m}^{-1} \text{ s}^{-2}
 \end{aligned}$$

Equations

$$pV = nRT$$

$$p = \frac{nRT}{V - nb} - a \left(\frac{n}{V} \right)^2$$

$$p_A = x_A p_T$$

$$x_A = \frac{n_A}{n_{\text{Total}}}$$

$$\Delta U = w + q$$

$$w = \int_{x_1}^{x_2} F \cdot dx$$

$$w = \int_0^Q \phi \cdot dQ'$$

$$w = - \int_{V_1}^{V_2} p_{\text{ext}} dV$$

$$C_p - C_V = nR$$

$$\Delta U = \int_{T_1}^{T_2} C_V dT$$

$$\Delta H = \int_{T_1}^{T_2} C_p dT$$

$$H = U + pV$$

$$\pi_T = \left(\frac{\partial U}{\partial V} \right)_T$$

$$p_1 V_1^\gamma = p_2 V_2^\gamma \quad \gamma = \frac{C_p}{C_V}$$

$$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2} \right)^{(\gamma-1)}$$

$$\Delta H_R^\circ = \sum_{\text{Products}} \nu \Delta H_f^\circ - \sum_{\text{Reactants}} \nu \Delta H_f^\circ$$

$$\Delta H_{r,T}^\circ = \Delta H_{r,298.15 \text{ K}}^\circ + \int_{T_1}^{T_2} \Delta C_p(T') dT'$$

$$\Delta C_p(T') = \sum_i \nu_i C_{p,i}(T')$$

$$\int x^n dx = \frac{1}{n+1} x^{n+1} + c$$

$$\int \frac{dx}{x} = \ln x + c$$

$$\frac{dx^n}{dx} = \frac{1}{n} x^{n-1}$$