

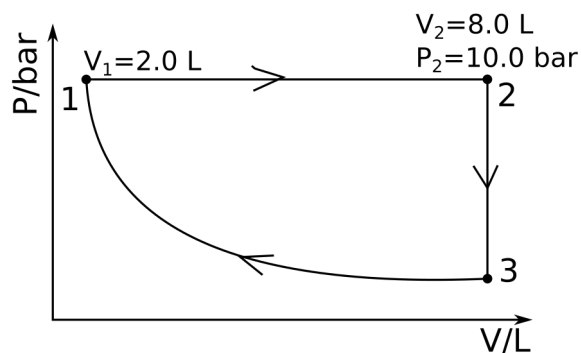
Name: _____

Answer all questions in the space provided. Show all work with ink, no white-outs, use back of the page when needed. Unexplained answers will not receive credit.

Total - 150 Pts.

Problem I**30 Pts**

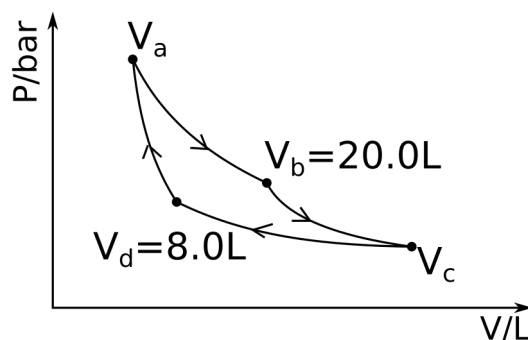
One mole of an ideal gas with $C_v = \frac{3}{2}R$ undergoes isobaric ($1 \rightarrow 2$), isochoric ($2 \rightarrow 3$) and isothermal ($3 \rightarrow 1$) transformations following the diagram:



1. Please calculate heat and work for each transformation, as well as total heat and work for the cycle. Calculate ΔU_{total} as well. // *Hint for quick calculations: $T = PV/R$ and let R 's cancel out. $1\text{bar} \cdot 1\text{L} = 0.1\text{kJ}$.*
2. Indicate for each step if the system performs work or the work is done on the system and indicate if the heat flows into or out of the system.
3. Calculate the change in the entropy for each step. Indicate if respective transformations are spontaneous or not. Should ΔS_{total} be zero or not?

Problem II**30 Pts**

The engine with a 1 mole of ideal gas with $C_{v,m} = \frac{5}{2}R$ as a working substance follows Carnot cycle shown below:



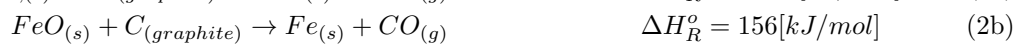
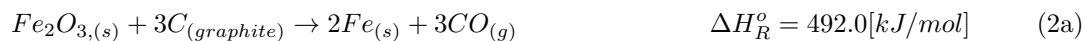
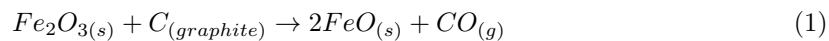
($a \rightarrow b$ and $c \rightarrow d$ are isothermal transformations at hot and cold temperatures respectively, whereas $b \rightarrow c$ and $d \rightarrow a$ are adiabatic transformations).

1. If the cycle works with 0.6 efficiency and the isothermal compression happens at 350 K, at what temperature the isothermal expansion occurs?
2. Calculate the gas volumes V_a and V_c , and work at isothermal expansion and compression steps.
3. How the efficiency of the cycle will change, if we replace the gas with a substance characterized by $C_{v,m} = \frac{3}{2}R$ assuming same T_c , T_h and V_b , V_d ? Please justify your answer.

Name: _____

Problem III**30 Pts**

1. From the data below, compute the ΔH_R° of the reaction at 298K as well as $\Delta H_f^\circ(Fe_2O_3, s)$ and $\Delta H_f^\circ(FeO, s)$:



2. Assuming that the ΔH_R° is independent of the temperature, explain how (a) increasing pressure or (b) increasing temperature affects the reaction equilibrium.

Problem IV**30 Pts**

CHEM352: PHYSICAL CHEMISTRY I

EXAM I - 9th OF OCT, 2018

Name: _____

Given the reaction:



and following data at 298K:

Compound	$CuO_{(s)}$	$Cu_{(s)}$	$O_{2(g)}$
$\Delta H_f^\circ [kJ \cdot mol^{-1}]$	-157		
$\Delta G_f^\circ [kJ \cdot mol^{-1}]$	-130		
$C_{P,m} [J \cdot K^{-1} \cdot mol^{-1}]$	42.3	24.4	29.4

1. Calculate the ΔH_R° of the reaction at 298 and 1298K. Assume that the heat capacities are temperature independent over the integration range.
2. Calculate the equilibrium constant at $T_o=298K$
3. Using the equation below, calculate the equilibrium constant at $T_f=1298K$:

$$\ln K_P(T_f) = \ln K_P(T_o) + \frac{1}{R} \int_{T_o}^{T_f} \frac{\Delta H_f(T)}{T^2} dT \quad (4)$$

Compute the $K_P(T_f)$ assuming that (1) the ΔH_R° is temperature-independent and (2) the ΔH_R° is temperature dependent: $\Delta H_f^\circ(T) = \Delta H_f^\circ(T_o) + \Delta C_{P,m} \cdot (T - T_o)$. Does temperature-dependence of the enthalpy of the reaction affect the K_P significantly?

Problem V**30 Pts**

CHEM352: PHYSICAL CHEMISTRY I

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1. Explain in terms of a physical processes they represent, why $C_{P,m}$ is always larger than $C_{V,m}$? (Writing that $C_{P,m} = C_{V,m} + R$ is not the answer).

2. Using properties of partial derivatives/cyclic rule, show that:

$$\left(\frac{\partial P}{\partial T}\right)_V = \frac{\beta}{\kappa} \quad (5)$$

Where β and κ are isobaric thermal expansion and isothermal compressibility respectively.

3. The total differential of entropy can be expressed using temperature and pressure:

$$dS = \left(\frac{\partial S}{\partial T}\right)_P dT + \left(\frac{\partial S}{\partial P}\right)_T dP \quad (6)$$

Using following equations:

$$dS = \frac{1}{T}dH - \frac{V}{T}dP \quad (7a)$$

$$dH = C_P dT + \left(\frac{\partial H}{\partial P}\right)_T dP \quad (7b)$$

show that:

$$\left(\frac{\partial S}{\partial T}\right)_P = \frac{C_P}{T} \quad (8a)$$

$$\left(\frac{\partial S}{\partial P}\right)_T = \frac{1}{T} \left(\left(\frac{\partial H}{\partial P}\right)_T - V \right) \quad (8b)$$