

$$R=8.314 \text{ units?} = 0.08206 \text{ units?}$$

$$1 \text{ atm} = 1.013 \times 10^5 \text{ N/m}^2$$

Do three (3) of the following four questions, if you answer more than three, cross out the one you wish not to be graded. (10 points each).

1. The heat effect at constant pressure is the _____ change.
A state function has a (pick one): a) exact ~~b) inexact~~ differential.

2. When 3 mol of O_2 is heated at constant pressure of 3.25 atm, its temperature increases from 260K to 285K. With $C_p=29.4 \text{ J mol}^{-1} \text{ K}^{-1}$, calculate q and ΔH .

3. One mole of an ideal monatomic gas expands from 1.00 L to 5.00 L at a constant temperature of 298.2 K. Calculate q , w , and ΔU if the gas expands against a constant external pressure of 1 atm. Make sure to give the answer in Joules.

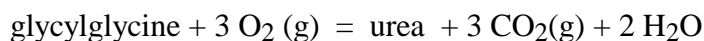
4. Assume you are making a pot of coffee. So you set a pot of water to boil on the stove. Which is larger for the process of boiling water, ΔU or ΔH and why? Talk about heat and work.

Part 2: Answer 5 of the following 6 questions. If you answer more than 5 cross out the one you don't want graded. 14 points each.

5. Use the following table for this problem:

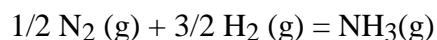
Compound	$\Delta_f H^\ominus$ (kJ mol ⁻¹)
Glycylglycine	-745.25
Urea	-333.0
CO ₂	-393.5
H ₂ O	-285.8

The combustion of sugars like glucose to give CO₂ and water is the major source of energy in cells. This energy source amounts to about 15 kJ g⁻¹ of sugar. Proteins can also be used as an energy source but the products are urea, CO₂ and H₂O(l). Compare the energy available from proteins with the energy available from sugars for equal weights of food. To do this calculate the enthalpy change for the following reaction on a per gram basis. Here glycylglycine represents the protein source. The molecular weight for glycylglycine is 132.1 g mol⁻¹.



6. The Haber process is used to manufacture ammonia. However, while the synthesis is done at 500°C, thermodynamic tables list the enthalpy of formation at 25°C. Estimate the enthalpy of formation of ammonia gas at 500°C. Use the estimates for the heat capacities:

$C_p(\text{N}_2) = C_p(\text{H}_2) = 7/2 nR$ and $C_p(\text{NH}_3) = 8/2nR$.



$$\Delta_f H^\ominus(\text{NH}_3, 298.2\text{K}) = -46.1 \text{ kJ/mol}$$

7. The enthalpy of formation of urea is $-333.0 \text{ kJ mol}^{-1}$. Calculate the internal energy of formation at the same temperature, 298.2 K . Urea is $\text{CH}_4\text{N}_2\text{O}$.

9. Calculate the change in entropy for 1.00 mole of ideal gas that is expanded against a constant external pressure of 1.00 atm from an initial pressure of 10.0 atm to a final pressure of 1.00 atm . During this process the temperature also drops from $25.00 \text{ }^\circ\text{C}$ to $0.00 \text{ }^\circ\text{C}$. The heat capacity is $C_p = 7/2 R$.

9. For a Van der Waals gas, $\left(\frac{\partial U}{\partial V}\right)_T = \frac{a}{V^2}$. Calculate ΔU for an isothermal expansion of nitrogen gas from an initial volume of V_1 to V_2 .

10. Show that $\left(\frac{\partial H}{\partial P}\right)_T = \left(\frac{\partial U}{\partial V}\right)_T \left(\frac{\partial V}{\partial p}\right)_T + p \left(\frac{\partial V}{\partial p}\right)_T + V$

[Show all your work with reasons for each step. For example: "since H is a state function" , "from the definition of heat capacity", or "dividing by dp gives the desired result". If you use a partial derivative relationship from "Further Information 1," if you choose not to derive the relationship, just state that you are using a relationship from "Further Information 1,"(FI1).]

Extra Credit 10 points.

The mass of a baseball is 145.0 g . A 100 mph fastball converts to 45.0 m/s. Calculate the mass of sugar that is needed to provide the energy (at 15 kJ g⁻¹ of sugar) for the pitcher to throw a baseball at 45.0 m/s.