

CHEMISTRY 202

Hour Exam II
October 26, 2023
Dr. D. DeCoste

Name **KEY**

Signature _____

T.A. _____

This exam contains 22 questions on 10 numbered pages. Check now to make sure you have a complete exam. You have two hours to complete the exam. Determine the **best** answer to the first 20 questions and enter these on the special answer sheet. Also, circle your responses in this exam booklet. **Show all of your work and/or provide complete answers to questions 21 and 22.**

1-20	(60 pts.)	_____
21	(30 pts.)	_____
22	(30 pts.)	_____
Total	(120 pts.)	_____

Useful Information:

- Always assume ideal behavior for gases (unless explicitly told otherwise).
- 760 torr = 1.00 atm
- $R = 0.08206 \text{ Latm/molK} = 8.314 \text{ J/Kmol}$
- $K = ^\circ\text{C} + 273$
- $N_A = 6.022 \times 10^{23}$

$$\Delta E = q + w$$

$$\Delta S = q_{\text{rev}}/T$$

$$H = E + PV$$

$$G = H - TS$$

Here are some of the formulas we used/derived in studying thermodynamics. An individual formula may or may not apply to a specific problem. This is for you to decide!

$$\Delta S = nR \ln(V_2/V_1)$$

$$\Delta S = \Delta H/T$$

$$C_v = (3/2)R$$

$$C_p = (5/2)R$$

$$\Delta S = nC \ln(T_2/T_1)$$

$$\Delta G = \Delta G^\circ + RT \ln(Q)$$

$$\Delta S_{\text{surr}} = -q/T$$

$$w = -P\Delta V$$

$$q_{\text{rev}} = nRT \ln(V_2/V_1)$$

$$q = nC\Delta T$$

$$\ln(K) = -\frac{\Delta H^\circ}{R} \left(\frac{1}{T} \right) + \frac{\Delta S^\circ}{R}$$

$$\ln \left(\frac{K_2}{K_1} \right) = -\frac{\Delta H^\circ}{R} \left(\frac{1}{T_2} - \frac{1}{T_1} \right)$$

1. The enthalpy of vaporization for a liquid at 298K is 100.0 kJ/mol. Determine ΔE for this process at 298K.

- a) 75.5 kJ/mol **b) 97.5 kJ/mol** c) 100.0 kJ/mol d) 102.5 kJ/mol e) 124.5 kJ/mol

2. In a coffee-cup calorimeter, a 3.14-g sample of a sodium hydroxide is dissolved in 100.0 g of water at an initial temperature of 25.0°C. Use the data below to determine the final temperature of the solution. Assume the specific heat capacity of the solution is constant at 4.18 J/g°C, that enthalpy values are independent of temperature, and that there is no heat transfer to or out of the calorimeter.

ΔH_f° (kJ/mol)	NaOH(s)	NaOH(aq)
	-427.0	-470.0

- a) 16.9°C b) 17.2°C c) 25.0°C **d) 32.8°C** e) 33.1°C

3. Given: $2\text{CO}(g) \rightarrow 2\text{C}(\text{graphite}) + \text{O}_2(g)$ $\Delta H^\circ = +222 \text{ kJ}$
 $2\text{CO}(g) + \text{O}_2(g) \rightarrow 2\text{CO}_2(g)$ $\Delta H^\circ = -566 \text{ kJ}$

Calculate the standard enthalpy of formation of $\text{CO}_2(g)$.

- a) -172 kJ/mol b) -344 kJ/mol **c) -394 kJ/mol** d) 172 kJ/mol e) 344 kJ/mol

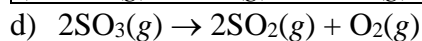
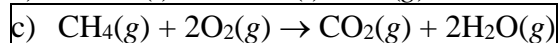
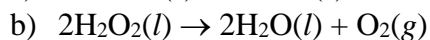
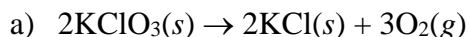
4. As we will see when we discuss electrochemistry in Chemistry 204 next semester, the value of ΔH_f° for $\text{H}^+(aq)$ is given as 0 (zero). The value of ΔH_{rxn}° for the reaction between magnesium metal and $\text{HCl}(aq)$, which produces $\text{MgCl}_2(aq)$ and hydrogen gas, is -462 kJ/mol. With this information, determine the value of ΔH_f° for $\text{Mg}^{2+}(aq)$.

- a) -924 kJ/mol **b) -462 kJ/mol** c) -231 kJ/mol d) 462 kJ/mol e) 924 kJ/mol

5. Suppose we use ΔH_f° values for a substance as a liquid and a vapor to estimate the value of $\Delta H_{\text{vaporization}}$ (that is we assume that the enthalpy values are temperature independent). How does the value of $\Delta H_{\text{vaporization}}$ for a substance at its boiling point without this assumption compare? Note: generally, the heat capacity of a substance as a liquid is greater than the heat capacity of that substance as a vapor.

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| <p>a) If the boiling point of the substance is below 25.0°C, the value of $\Delta H_{\text{vaporization}}$ at the boiling point is greater than the value we get if we assume temperature independence. If the boiling point of the substance is above 25.0°C, the value at the boiling point is smaller.</p> |
| <p>b) If the boiling point of the substance is below 25.0°C, the value of $\Delta H_{\text{vaporization}}$ at the boiling point is smaller than the value we get if we assume temperature independence. If the boiling point of the substance is above 25.0°C, the value at the boiling point is greater.</p> |
| <p>c) The value of $\Delta H_{\text{vaporization}}$ at the boiling point is always greater than the value we get if we assume temperature independence, no matter the boiling point.</p> |
| <p>d) The value of $\Delta H_{\text{vaporization}}$ at the boiling point is always smaller than the value we get if we assume temperature independence, no matter the boiling point.</p> |

6. For which of the following reactions, at constant temperature and pressure, is the value of ΔH° closest to the value of ΔE° ?



e) For a chemical reaction the values of ΔH° and ΔE° are always the same.

7. Use the following data to determine the value of S° for $\text{H}_2\text{O}(s)$. Assume ΔH and ΔS are temperature independent.

	$\text{H}_2\text{O}(l)$	$\text{H}_2\text{O}(s)$
ΔH_f° (kJ/mol)	-286	-292
S° (J/Kmol)	70.0	?

a) -22.0 J/K b) 20.0 J/K c) 22.0 J/K d) 48.0 J/K e) 92.0 J/K

8. Consider the one-step isothermal expansion and then one-step isothermal compression of 1.00 mole of an ideal, monatomic gas such that volume of the gas is the same before and after the process. For how many of the following: q , ΔH , ΔS , and ΔG , are the magnitudes of the values the same in the expansion and compression?

a) 0 b) 1 c) 2 d) 3 e) 4

9 – 12. Consider a 1.000 mole sample of an ideal, monatomic gas in a steel rigid container at 1.000 atm that is currently at 250.0°C. The container with the gas is moved outside and allowed to come to equilibrium with the new environment (1.000 atm and 25.0°C). Assume the container is a perfect conductor of heat.

9. Determine ΔH for the process that occurs.

a) -4.677 kJ b) -2.806 kJ c) 1.871 kJ d) 2.806 kJ e) 4.677 kJ

10. Determine ΔS for the process that occurs.

a) -11.69 JK b) -7.015 J/K c) 4.677 J/K d) 7.015 J/K e) 11.69 J/K

11. Determine ΔS_{surr} for the process that occurs.

a) -8.943 J/K b) 0 J/K c) 8.943 J/K d) 9.416 J/K e) 15.69 J/K

12. Determine ΔG for the process that occurs. Note: at 25.0°C, $S^\circ = 65.0$ J/K for the gas.

a) -2.586 kJ b) -715.5 J c) 0 kJ d) 2.586 kJ e) 13.62 kJ

13. For which of the following is the difference between the value of ΔG_f° and the value of ΔH_f° (both in units of kJ/mol) closest to zero?

- a) $\text{NH}_3(g)$ b) $\text{N}_2\text{H}_4(l)$ c) $\text{H}_2\text{O}(g)$ d) $\text{H}_2\text{O}(l)$ e) $\text{HF}(g)$
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14 – 15. At constant pressure and temperature, the reaction $2\text{HF}(g) \rightarrow \text{H}_2(g) + \text{F}_2(g)$ is **not spontaneous at any temperature**.

14. Given that ΔH_f° for $\text{HF}(g) = -271$ kJ/mol, which of the following is true about the value of ΔG_f° for $\text{HF}(g)$ in units of kJ/mol?

- a) The sign of ΔG_f° for $\text{HF}(g)$ is negative and the magnitude (absolute value) is greater than 271.
b) The sign of ΔG_f° for $\text{HF}(g)$ is positive and the magnitude (absolute value) is greater than 271.
c) The sign of ΔG_f° for $\text{HF}(g)$ is negative and the magnitude (absolute value) is less than 271.
d) The sign of ΔG_f° for $\text{HF}(g)$ is positive and the magnitude (absolute value) is less than 271.
e) We cannot tell anything from this information about ΔG_f° for $\text{HF}(g)$.

15. Given that the values of S° for $\text{H}_2(g)$ and $\text{F}_2(g)$ are 131 J/K and 203 J/K, respectively, which of the following is true about the value of S° for $\text{HF}(g)$?

- a) The minimum possible value of S° for $\text{HF}(g)$ is +167 J/K.
b) The maximum possible value of S° for $\text{HF}(g)$ is +167 J/K.
c) The only possible value of S° for $\text{HF}(g)$ is exactly +167 J/K.
d) We cannot determine the magnitude of S° for $\text{HF}(g)$, but the sign must be negative.
e) We cannot tell anything from this information about S° for $\text{HF}(g)$.
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16 – 17. You are filling a balloon with helium, and you inflate it to 31.4 L at 1.00 atm and 25°C. You are filling it from a 100.0-L tank that is initially at 25.0 atm and 25°C. Determine:

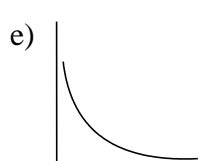
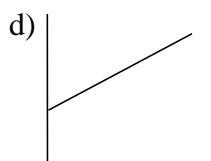
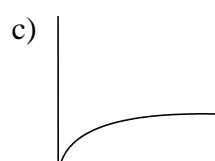
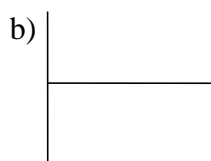
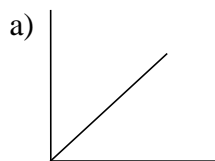
16. ΔS for the helium filling the balloon.

- a) 0 J/K b) 26.8 J/K c) 34.4 J/K d) 51.5 J/K e) 66.9 J/K

17. ΔS for the helium remaining in the tank.

- a) -23.3 J/K b) 0 J/K c) 10.6 J/K d) 23.3 J/K e) 26.8 J/K

18-20. Indicate which of the graphs below best represents each plot described in questions 18, 19, and 20. Note: the graphs may be used once, more than once, or not at all.



18. Magnitude of work (y) vs. the number of steps (x) for the isothermal compression of one mole of an ideal, monatomic gas. e
19. Enthalpy, H , (y) vs. pressure, P , (x) for one mole of an ideal monatomic gas at constant temperature, T . b
20. $\ln(K)$ (y) vs. $1/T$ (x) for an exothermic chemical reaction. d