

Chemistry 102b First Exam

PRINT your name _____

"I have neither given or received unauthorized aid on this examination"

Sign if upheld _____

CIRCLE the section in which you are officially registered:

Section 1-Rosenthal

Section 2-Phillips

Section 3-Stone

Gas constant: $R = 0.08206 \text{ L-atm/mol K}$, or $R = 8.314 \text{ J/mol K}$ $1 \text{ L-atm} = 101.325 \text{ J}$

GMW of O: 15.999 GMW of H: 1.008 GMW of Na: 22.990 GMW of N: 14.007

Thermodynamic data you may need for this examination:

Specific Heat Capacity at 25 °C

Substance	c_s (J/K g)
Cu(s)	0.385
Fe(s)	0.449
O ₂ (g)	0.917
H ₂ O(l)	4.18

Average Bond Enthalpies (kJ/mol)

<u>C-H</u>	<u>C-O</u>	<u>C=O</u>	<u>H-O</u>	<u>O-O</u>	<u>O=O</u>
413	351	728	463	139	498

Section I. True/False 2pts each, 20pts total. CIRCLE the correct answer.

- 1) The specific heats of water and iron are 4.184 and 0.444 J/g°C, respectively. When equal masses of water and iron both absorb the same amount of heat, the temperature increase of the water will be 5.42 times greater than that of the iron.
TRUE FALSE
- 2) The entropy change ΔS° for the reaction $\text{NH}_4\text{Cl}(s) \rightarrow \text{NH}_3(g) + \text{HCl}(g)$ will be negative..
TRUE FALSE
- 3) Gas confined in a cylinder is compressed from 10.0 L to 1.0 L. Work is done on the system and the internal energy is decreased.
TRUE FALSE
- 4) All exothermic reactions are spontaneous.
TRUE FALSE
- 5) For the process $\text{CO}_2(s) \rightarrow \text{CO}_2(g)$, you should expect the signs of ΔH and ΔS to be the same.
TRUE FALSE
- 6) $\Delta H_{\text{vap}} > 0$ for all vaporization processes.
TRUE FALSE
- 7) An increase in the Gibbs free energy for a reaction indicates the reaction is spontaneous.
TRUE FALSE
- 8) $\Delta E = q + w$ is a statement of the first law of thermodynamics.
TRUE FALSE
- 9) The third law of thermodynamics states that a spontaneous process is always accompanied by an increase in the entropy of the universe.
TRUE FALSE
- 10) For a reaction with $\Delta H < 0$, increasing the temperature of the reaction will force the equilibrium to shift towards the products.
TRUE FALSE

Section II. Short answer. CLEARLY Circle the Correct Answer. 2pts. Each, 20pts Total.

- 1) For a reaction with $\Delta S > 0$ and $\Delta H > 0$, this reaction will be spontaneous at:
HIGH TEMPERATURES LOW TEMPERATURES
- 2) A commercial heat pack is a device containing a saturated solution of sodium acetate which crystallizes spontaneously when activated. This is a ENDOTHERMIC/EXOTHERMIC reaction.
- 3) Water has a large heat capacity. Because of this the lake shore temperature is HIGHER/LOWER than the inland temperature in the summer.
- 4) Completely dissociating a C-C bond into two atoms of carbon requires LESS/MORE energy than completely dissociating a C=C bond.
- 5) Gun cotton is a solid which violently combusts to give gaseous products. For this reaction entropy:
INCREASES DECREASES

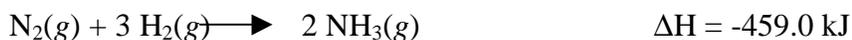
Consider the combustion of gasoline. This reaction CAN/CANNOT do pressure-volume work.

- 7) For a chemical reaction occurring at constant pressure, the transfer of heat to or from the surroundings of the chemical reaction is equal to: ENTHALPY WORK
- 8) If a balloon is compressed to $4/5$ ths it's original volume, the internal energy of the balloon:
INCREASES DECREASES
- 9) For a chemical reaction at equilibrium: $\Delta G = 0$ $\Delta S_{\text{sys}}=0$
- 10) When the temperature of a gas is elevated:
ENTROPY INCREASES ENTORPY DECREASES DOESN'T CHANGE

Section III. Multiple Choice. 4pts each, 40 pts total.

CIRCLE ONLY THE CORRECT ANSWER!! **If you circle two answers YOU WILL RECEIVE NO CREDIT!**

1. Which one of the following statements is not true concerning the equation below?

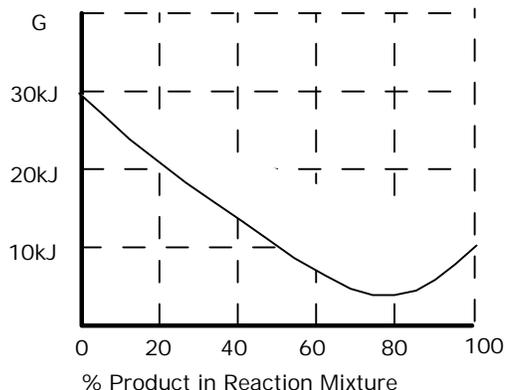


- a. The complete reaction of 1.00 mole of nitrogen produces 459 kJ of heat.
- b. The complete reaction of 1.00 mole of hydrogen produces 153 kJ of heat

A

- c. The production of 1.00 mole of ammonia is accompanied by the production of 229.5 kJ of heat.
- d. The complete reaction of 0.8278 moles of hydrogen requires 0.2759 moles of nitrogen.
- e. All of these are true statements.
2. For the reaction $\text{H}_2(\text{g}) + \text{S}(\text{s}) \rightarrow \text{H}_2\text{S}(\text{g})$ $\Delta H^\circ = -20.2 \text{ kJ/mol}$ and $\Delta S^\circ = +43.1 \text{ J/Kmol}$. Which of the following statements is true?
- a. The reaction is only spontaneous at low temperatures.
- b. The reaction is spontaneous at all temperatures.
- c. ΔG° becomes less favorable at T is raised.
- d. The reaction is spontaneous only at high temperatures.
- e. The reaction is at equilibrium at 25 °C under standard conditions.
3. A spontaneous endothermic reaction always
- a. Causes the surroundings to get colder.
- b. Occurs rapidly in the reverse direction.
- c. Releases heat to the surroundings.
- d. Occurs rapidly in the forward direction.
- e. None of the above.
4. A chemical process releases 20 kJ of heat and does 10 kJ of work on its surroundings. What is the change in internal energy of the system?
- a) +30kJ b) +10 kJ c) -10kJ d) -30 kJ e) not enough information
- 5) A 25 g piece of copper at 135.0 °C is plunged into 100 g of water at 25.0°C. Assuming no heat is lost to the surroundings, what will the final temperature of the system be?
- a) 22.4°C
- b) 27.5°C
- c) -21.3°C
- d) 37.2°C
- e) none of these
- 6) If K_p for the reaction $\text{N}_2\text{O}_4(\text{g}) \rightarrow 2\text{NO}_2(\text{g})$ is 0.15 at 25°C, calculate G_r° for this reaction.
- a) 4.7 kJ b) -2.0 kJ c) -0.4 kJ d) 2.0 kJ e) -4.7 kJ

7) Consider the following plot of reaction free energy vs. % products in the reaction mixture:



Calculate ΔG for this reaction:

- a) 0 kJ b) 20kJ c) -20kJ d) 25kJ e) -25kJ

8) Calculate G_r° for the decomposition of mercury(II) oxide at 298 K.

	2HgO(s)	\longrightarrow	2Hg(l)	$+$	$\text{O}_2\text{(g)}$
$H_f^\circ, \text{kJ} \cdot \text{mol}^{-1}$	-90.83		0.0		0.0
$S_m^\circ, \text{J K}^{-1} \text{mol}^{-1}$	70.29		76.02		205.14

- a) +246.2 kJ b) -117.1 kJ c) -246.2 kJ d) -64.5 kJ e) +117.1 kJ

9) In any spontaneous process,

- a) the path between reactants and products is irreversible
 b) the path between reactants and products is reversible
 c) reactants and products are in equilibrium
 d) both forward and reverse reactions are spontaneous

10) The thermite reaction is an example of a enthalpy-driven spontaneous process. Two solids react to form two other solids. The reaction is violent and enough heat is liberated to melt one of the solid products. From this information one can deduce:

- a) The entropy of the system increases
 b) The entropy of the universe increases
 c) The Gibbs free energy decreases

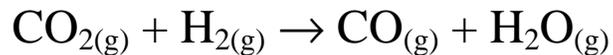
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- d) All of the above
- e) Answers b and c are both correct

A

Section IV. Show your work to receive full credit! 10pts.

An equilibrium mixture at 727 °C contains 0.276 mol H₂, 0.276 mol CO₂, 0.224 mol CO, and 0.224 mol H₂O.



What is the value of ΔG° at 727 °C?

$\Delta G^\circ =$ _____

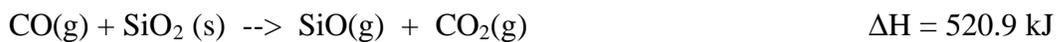
In what direction will a net chemical change occur if one brings together 0.0500 mol CO₂, 0.0700 mol H₂, 0.0400 mol CO, and 0.0850 mol H₂O? (CIRCLE ONE)

TOWARDS REACTANTS

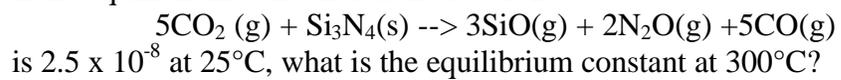
TOWARDS PRODUCTS

A

Section V. Show your work to receive full credit. 10pts.



If the equilibrium constant for the reaction:



A

If anything on this exam was poorly worded or confusing, or you believe you found a mistake, explain your answer below.

Indicate Points Missed

Section I _____

Section II _____

Section III _____

Section IV _____

Section V _____

Score: _____/100

Print your name, Last Name First
