


January 30, 2009


Name: \_\_\_\_\_  
Last Name First Name

Perm # \_\_\_\_\_

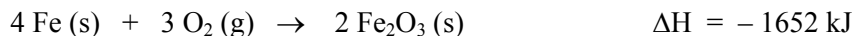
There are a total of six pages (21 questions) on the exam. You must show your work on the exam. We can evaluate your exam only if you have shown work.

**SCANTRON FORM:**Completely fill bubbles 

1) Write your name

Completely fill answers 2) Bubble in **FORM A**3) Bubble in your **PERM** number (7 digits only, no extra numbers)**INFORMATION PAGE:** Remove the information page. No other notes or books are allowed.**INSTRUCTIONS:** No hats/hoods allowed. No sharing of calculators. Cell Phones, iPods, headsets, and any other electronic devices must be turned off and put away.

1. (6 pts) Consider the reaction.



Calculate the heat of reaction when five moles of Fe (s) reacts with excess O<sub>2</sub> (g). Assume the reaction goes to completion.

- a) - 1239 kJ
- b) - 2203 kJ
- c) - 1322 kJ
- d) - 1652 kJ
- e) - 2065 kJ

**ANSWERS are at the end of the exam**

2. (4 pts) What is the sign of work for the process in which 2.0 moles of an ideal gas is cooled from 160 °C to 50 °C at constant pressure.

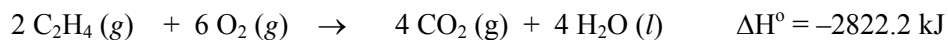
- a)  $w > 0$
- b)  $w < 0$
- c)  $w = 0$

**Questions 3 – 5:** (3 pts each) Nitrogen gas is heated first at constant volume and then at constant pressure.

Which of the following statements are true?

3. The heat,  $q$ , for the process at constant volume is equal to the change in internal energy,  $\Delta E$ , for the process at constant pressure.
  - a) True
  - b) False
  
4. The change in enthalpy,  $\Delta H$ , for the process at constant pressure is equal to the change in internal,  $\Delta E$ , for the process at constant volume.
  - a) True
  - b) False
  
5. For the process at constant volume work is zero,  $w = 0$ , whereas for the process at constant pressure, work is greater than zero,  $w > 0$ .
  - a) True
  - b) False
  
6. (6 pts) The molar heat capacities for  $N_2$  gas at  $25^\circ C$  are,  $C_v = 20.8 \text{ J K}^{-1} \text{ mol}^{-1}$  and  $C_p = 29.1 \text{ J K}^{-1} \text{ mol}^{-1}$ . What is the change in internal energy,  $\Delta E$ , when one mole of a  $N_2$  gas is heated from  $25^\circ C$  to  $50^\circ C$  at constant pressure?
  - a) + 728 J
  - b) - 728 J
  - c) - 520 J
  - d) + 520 J
  - e) none of the above
  
7. (6 pts) Suppose you add 45 J of heat to a system, let it do 10. J of expansion work, then you return the system to its initial state by cooling and compression. Which statement is true for this process?
  - a)  $\Delta H < \Delta E$
  - b) The work done in compressing the system must exactly equal the work done by the system in the expansion step.
  - c)  $\Delta H = 70. \text{ J}$
  - d) The change in the internal energy for this process is zero.
  - e) None of these

8. (6 pts) Given the following standard enthalpies, calculate the standard enthalpy of formation,  $\Delta H_f^\circ$ , of  $C_2H_4$ .



	$\Delta H_f^\circ$ (kJ/mol)
$CO_2(g)$	-393.5
$H_2O(l)$	-285.9

- a) -104.6 kJ/mol
  - b) -52.3 kJ/mol
  - c) +2143 kJ/mol
  - d) +52.3 kJ/mol
  - e) +104.6 kJ/mol
9. (6 pts) For  $NH_3(g)$ , the standard enthalpy of formation,  $\Delta H_f^\circ = -46 \text{ kJ/mol}$ . Calculate the heat of reaction when 1.00 mole of hydrogen gas reacts with excess nitrogen gas to form  $NH_3$  at 298 K and a constant pressure of 1.00 atm.

- a) +46 kJ
- b) -92 kJ
- c) +31 kJ
- d) -46 kJ
- e) -31 kJ

10. (6 pts) Consider the following reaction at 25 °C.  $CO(g) + H_2(g) \rightarrow H_2CO(g)$

For this reaction  $\Delta H^\circ = -5.36 \text{ kJ}$  and  $\Delta S^\circ = -109.8 \text{ J/K}$ . At what temperatures will the reaction be spontaneous?

- a)  $T > 48.8 \text{ K}$
- b)  $T < 48.8 \text{ K}$
- c)  $T > 20.5 \text{ K}$
- d)  $T < 20.5 \text{ K}$
- e) Spontaneous at all temperatures.

11. (6 pts) For an exothermic reaction to be nonspontaneous at high temperatures, what must the signs be for  $\Delta H$  and  $\Delta S$ .

- a)  $\Delta H > 0$  and  $\Delta S > 0$
- b)  $\Delta H > 0$  and  $\Delta S < 0$
- c)  $\Delta H < 0$  and  $\Delta S > 0$
- d)  $\Delta H < 0$  and  $\Delta S < 0$

12. (6 pts) Consider the following reaction at 800 K.  $2 \text{NF}_3(g) \rightarrow \text{N}_2(g) + 3 \text{F}_2(g)$   
At equilibrium, the partial pressures are  $P_{\text{N}_2} = 0.040$  atm,  $P_{\text{F}_2} = 0.063$  atm and  $P_{\text{NF}_3} = 0.66$  atm.  
The value of  $\Delta G^\circ$  \_\_\_\_\_.

- a) is a positive number
- b) is a negative number
- c) is equal to zero
- d) is independent of the temperature
- e) can not be predicted from this data

**Questions 13 – 15:** (3 pts each) Consider the freezing of liquid water at  $-10^\circ\text{C}$  and 1 atm. For this process, what are the signs of  $\Delta H$ ,  $\Delta S$  and  $\Delta G$ ?

13. a)  $\Delta H > 0$             b)  $\Delta H < 0$

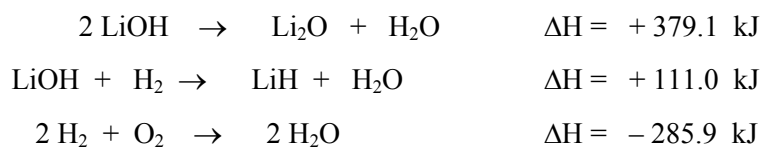
14. a)  $\Delta S > 0$             b)  $\Delta S < 0$

15. a)  $\Delta G > 0$             b)  $\Delta G < 0$

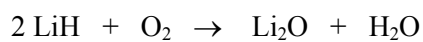
16. (6 pts) The dissociation of hydrogen,  $\text{H}_2(\text{g}) \rightarrow 2\text{H}(\text{g})$

- a) is spontaneous at all temperatures.
- b) is spontaneous at high temperature.
- c) is spontaneous at low temperatures.
- d) is not spontaneous at any temperature.

17. (6 pts) Given the following data at 25 °C:

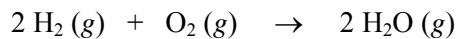


Calculate the  $\Delta\text{H}$  for the following reaction.



- a) +204.2 kJ
- b) -128.8 kJ
- c) +315.2 kJ
- d) -17.8 kJ
- e) none of these

**Questions 18– 19:** (3 pts each) Predict the signs of  $\Delta\text{H}$  and  $\Delta\text{S}$  for the combustion of hydrogen at 25 °C and 1 atm constant pressure.



18. a)  $\Delta\text{H} > 0$       b)  $\Delta\text{H} < 0$

19. a)  $\Delta\text{S} > 0$       b)  $\Delta\text{S} < 0$

20. (6 pts) Consider the following reaction:  $2 \text{NO}_2 (g) \rightleftharpoons \text{N}_2\text{O}_4 (g)$

For this reaction at 298 K,  $\Delta H^\circ = -56.8 \text{ kJ}$  and  $\Delta S^\circ = -175 \text{ J/K}$ .

In a container at 298 K,  $\text{N}_2\text{O}_4 (g)$  is mixed with  $\text{NO}_2 (g)$ . The initial partial pressures are:  $P_{\text{N}_2\text{O}_4} = 2.4 \text{ atm}$  and  $P_{\text{NO}_2} = 0.42 \text{ atm}$ . Which of the following statements is correct?

- a) Some  $\text{N}_2\text{O}_4 (g)$  will decompose into  $\text{NO}_2 (g)$
- b) Some  $\text{NO}_2 (g)$  will react to produce  $\text{N}_2\text{O}_4 (g)$ .
- c) The system is at equilibrium at these initial pressures.
- d) The final total pressure must be known to answer this question.
- e) None of these

21. (6 pts) Consider the following reaction  $2 \text{SO}_2 (g) + \text{O}_2 (g) \rightarrow 2 \text{SO}_3 (g)$

For this reaction  $\Delta H^\circ = -200. \text{ kJ}$  and  $\Delta S^\circ = -187 \text{ J/K}$  at  $25^\circ \text{C}$ . Assuming that  $\Delta H^\circ$  and  $\Delta S^\circ$  are independent of temperature, calculate the temperature where  $K_p = 1$ .

- a) 970 K
- b) 2070 K
- c) 200 K
- d) 1070 K
- e) None of these

**ANSWERS:** 1. e   2. a   3. a   4. b   5. b   6. d   7. d   8. d   9. e   10. b   11. d   12. a  
13. b   14. b   15. b   16. b   17. b   18. b   19. b   20. a   21. d

**Partial Credit:** 8 b (3 pts)      8 e (3 pts)      9 c (3 pts)      10 a (3 pts)