

Chemistry 1210 R50
Fall 2000
Test #3

Thursday, November 23, 2000

Time: 2 hours

Name: _____

Student Number: _____

*This exam consists of **eight** pages of questions, a page of thermodynamic data, the formula sheet, and a periodic table. Please ensure that you have a complete paper and, if you do not, obtain one from me **immediately**. Good luck!*

- 1) [3 marks] Given that the vapour pressure of methanol is 380 mmHg at 47.5°C, complete the following table for the reaction:

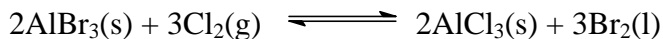


Your choices are + (greater than zero), - (less than zero), or 0.

T (°C)	ΔH	ΔS	ΔG
25.0			
47.5			
70.0			

[Ans.: ΔH : + + +; ΔS : + + +; ΔG : + 0 -]

2) **[9 marks total]** For the reaction



at 25°C:

a) **[3 marks]** Calculate ΔH° , ΔS° , and ΔG° .

[Ans.: ΔH° : -388.7 kJ; ΔS° : -354.1 J/K; ΔG° : -283.1 kJ]

b) **[1 mark]** Calculate K_p .

[Ans.: 3.988×10^{49}]

c) **[2 marks]** If this reaction were used in a battery, what voltage would it produce under standard conditions?

[Ans.: +0.489 V]

d) **[1 mark]** Calculate ΔG for a pressure of $\text{Cl}_2(\text{g}) = 0.500 \text{ atm}$.

[Ans.: -278.0 kJ]

e) **[2 marks]** If all but the Cl_2 pressure are held at standard conditions, what must be the pressure of Cl_2 to make the reaction non-spontaneous?

[Ans.: $2.93 \times 10^{-17} \text{ atm}$]

3) **[8 marks total]** The vapour pressure of $\text{Br}_2(\text{l})$ is 215.2 mmHg at 298.15 K.

a) **[3 marks]** What is the normal boiling point of $\text{Br}_2(\text{l})$?

[Ans.: 58.6°C]

b) **[3 marks]** What is S°_{f} for $\text{Br}_2(\text{g})$?

[Ans.: 245.4 J/K]

c) **[2 marks]** Does your answer for part c) agree with what you'd predict using Trouton's Rule? Why or why not?

4) [5 marks total] For the mythical reaction



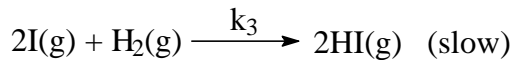
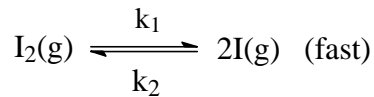
The following data were collected at 25.0°C (all concentrations have units of M and all rates have units of M/s):

[A]	[D]	rate of appearance of D	rate of disappearance of A
P	R		-4S
2P	R	8S	
3P	2R		-54S
4P	2R		

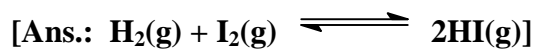
a) [3 marks] Complete the table above.
[Ans.: D: S, 13.5S, 32S; A: -32S, -128S]

b) [2 marks] Determine the units for the rate constant.
[Ans.: $M^{-1}s^{-1}$]

5) [5 marks] I₂ and H₂ react to form HI via the following mechanism:



a) [1 mark] What is the overall reaction?



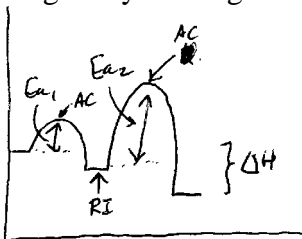
b) [1 mark] Identify any reactive intermediates.

[Ans.: I]

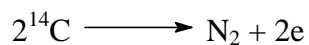
c) [3 marks] What is the rate law for this reaction?

[Ans.: rate = $k[\text{H}_2][\text{I}_2]$]

6) [4 marks] Sketch the activation energy diagram you would expect to see for the mechanism in the previous question. Assume that both steps are exothermic. Label where any reactive intermediates, activated complexes, and activation energies appear in the sketch. Mark the range on your diagram that corresponds to ΔH for the overall reaction.



- 7) **[4 marks]** Radioactive decay has been found to follow first order kinetics. ^{14}C has a half-life of 5760 years and decays to ^{14}N according to the reaction:



If the pressure is held constant at 1.00 atm and you start with 100.0 moles of ^{14}C , how long will it take before the volume of N_2 evolved is 0.02 litres per year at 25°C ?

[Ans.: 16,587 years]

- 8) **[2 marks]** True or false: In the presence of a catalyst, a reaction may slow down after a period of time. Explain your choice.

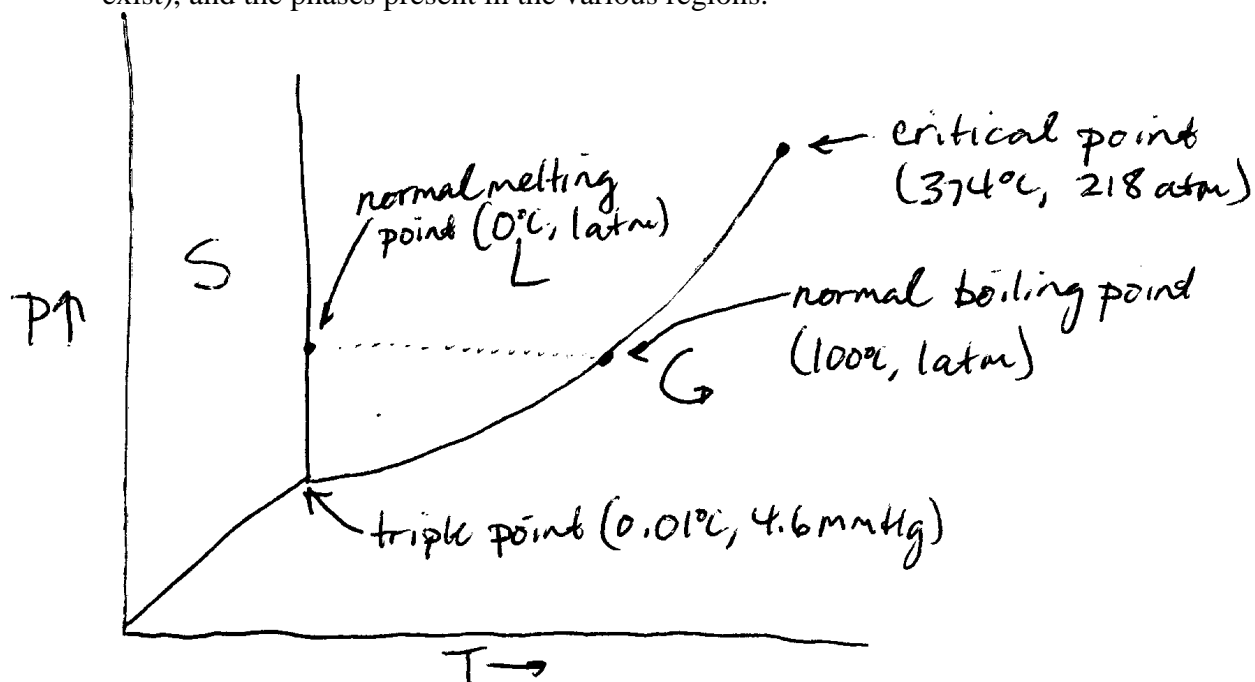
[Ans.: true]

9) **[3 marks]** In the absence of a catalyst, a certain reaction has an activation energy of 380 kJ/mol. In the presence of a catalyst, the reaction has an activation energy of 180 kJ/mol. At what temperature would the reaction have to be run in the absence of a catalyst to have the same rate as when it is run in the presence of a catalyst at 25°C?

[Ans.: 629.4 K]

10) [9 marks total] The critical temperature and pressure for water are 374°C and 218 atm respectively. The triple point for water is at a temperature of 0.01°C and a pressure of 4.6 mmHg. The normal melting point for water is at 0.0°C .

- a) [5 marks] Sketch the phase diagram for water. Indicate on your graph the triple point, the critical point, the normal melting, boiling, and sublimation points (as and when they exist), and the phases present in the various regions.



- b) [2 marks] Estimate ΔH_{vap} for H_2O .
[Ans.: 41.2 kJ]

- c) [2 marks] ΔH_{fus} for H_2O is 6.01 kJ/mol. Estimate ΔH_{sub} for H_2O .
[Ans.: 47.2 kJ]

Thermochemical Data

All data for a temperature of 25°C

Chemical	$\Delta H_f^\circ(\text{kJ/mol})$	$S_f^\circ(\text{J/mol-K})$
AlCl ₃ (s)	-705.6316	109.29
AlBr ₃ (s)	-511.2848	180.03
Cl ₂ (g)		223.08
Br ₂ (l)		152.21
Br ₂ (g)	30.91	