

\*\*KEEP YOUR WORK AND ANSWERS COVERED.\*\*

1. (30 pts) Indicate whether each statement is true (T) or false (F). Be certain T or F is clearly indicated.

- F For a pure substance,  $\Delta S_{\text{fus}}^{\circ} > \Delta S_{\text{vap}}^{\circ}$ .
- F For every process,  $\Delta S_{\text{sys}} = -\Delta S_{\text{surr}}$ .
- T For any exergonic reaction, the maximum driving force is at the start of the reaction.
- F All simple mechanisms are unimolecular.
- F Faster reactions have longer half-lives.
- T For every elementary reaction,  $\Delta H = E_{\text{a,fwd}} - E_{\text{a,rev}}$ .
- T The industrial production of  $\text{NH}_3$  requires a catalyst.
- T Small changes in  $\Delta G^{\circ}$  can lead to large changes in  $K$ .
- F At equilibrium, at the normal boiling point of any liquid,  $K = \text{zero}$ .
- T When you reverse an equation, then  $Q$  is inverted.

- \*\* 2. (6 pts) The following equation is balanced.



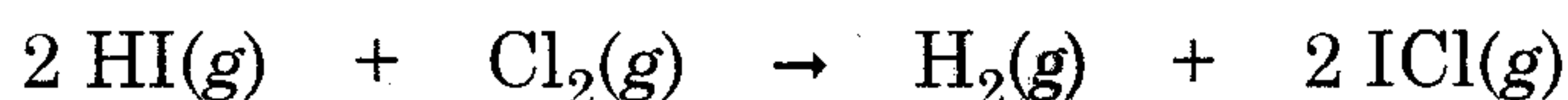
For the following conditions, circle the value of  $Q$  below.

0.442 atm $\text{O}_2$	11.3 mol $\text{H}_2\text{O}$	1.46 g $\text{MnO}_2$	0.0438 M $\text{H}^+$	0.0243 M $\text{Mn}^{2+}$
63.1	<u>70.9</u>	104	188	252
336	371	448	470.	522
				287
				566

3. (6 pts) Consider the following formation equations with their equilibrium constants at 298.15 K.

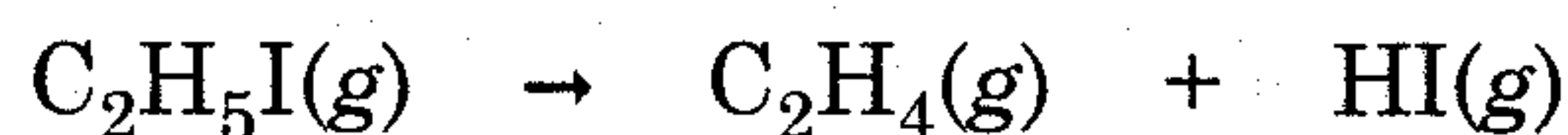


Use these to calculate (and circle below) the equilibrium constant of the following reaction.



18.9	40.6	90.2	118	147	180.
231	262	274	331	<u>359</u>	392

- \*\* 4. (10 pts) The following reaction is first order in  $C_2H_5I$ ;  $k = 4.0 \times 10^{-3} s^{-1}$  at 700 K.



The reaction begins with  $[C_2H_5I] = 3.30 \times 10^{-4} mol/L$ . Circle the concentration (in mol/L) of  $C_2H_5I$  which remains after 300. s.

$1.7 \times 10^{-5}$     $2.2 \times 10^{-5}$     $3.0 \times 10^{-5}$     $4.7 \times 10^{-5}$     $5.6 \times 10^{-5}$     $6.4 \times 10^{-5}$   
 $7.2 \times 10^{-5}$     $8.6 \times 10^{-5}$     $9.9 \times 10^{-5}$     $1.3 \times 10^{-4}$     $1.6 \times 10^{-4}$     $1.9 \times 10^{-4}$

Circle the concentration (in mol/L) of HI which has formed in 300. s. (Above answer must be correct for credit here.)

$1.40 \times 10^{-4}$     $1.70 \times 10^{-4}$     $2.00 \times 10^{-4}$     $2.31 \times 10^{-4}$     $2.44 \times 10^{-4}$     $2.58 \times 10^{-4}$   
 $2.66 \times 10^{-4}$     $2.74 \times 10^{-4}$     $2.83 \times 10^{-4}$     $3.00 \times 10^{-4}$     $3.08 \times 10^{-4}$     $3.13 \times 10^{-4}$

5. (6 pts) Give the sign of  $\Delta S^\circ$  for each of the following processes.

Combustion reaction of  $H_2S(g)$   
to  $SO_2(g)$  and  $H_2O(g)$

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Condensation

—

Dissolving  $Ar(g)$  into water

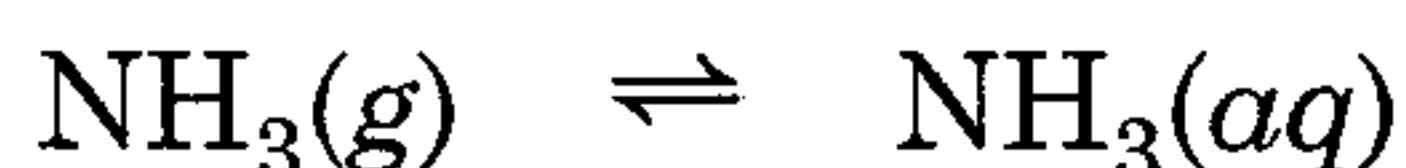
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- \*\* 6. (6 pts) Circle the value of  $\Delta S^\circ_{rxn}$  (in J/K) for the following balanced equation.



$137.22$     $153.18$     $170.61$     $196.41$     $221.70$     $243.05$   
 $268.17$     $287.51$     $307.63$     $318.01$     $337.52$     $356.19$

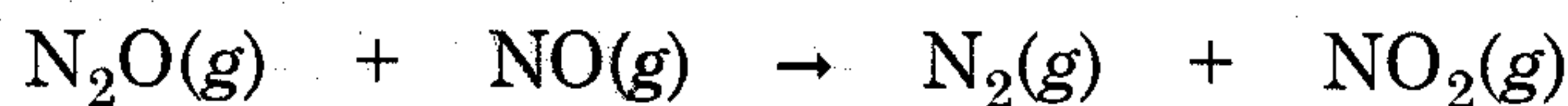
- \*\* 7. (6 pts) Consider the solubility equilibrium of  $NH_3(g)$  in water at 298 K.



Circle the value of  $K$ .

$13.2$     $18.0$     $23.6$     $26.3$     $30.7$     $38.2$   
 $42.9$     $46.1$     $54.8$     $59.7$     $63.8$     $68.0$

8. (8 pts) The following is an elementary step.



Write the rate law.

$$k[\text{N}_2\text{O}][\text{NO}]$$

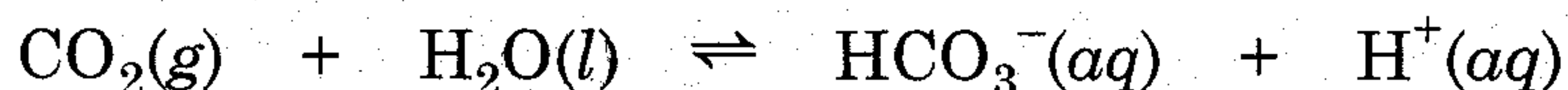
What is the overall order of the step?

2

What free radicals are involved?

NO, NO<sub>2</sub>

9. (10 pts) The following equation is balanced.

Circle the value of  $\Delta G^\circ$  in kJ.

26.37	27.28	31.34	35.45	<u>44.76</u>	49.67
55.08	57.93	62.18	67.50	73.41	76.98

For the following conditions at 298.15 K, circle  $\Delta G$  (in kJ). (Above answer must be correct for credit here.)

0.603 atm CO <sub>2</sub>	250. g H <sub>2</sub> O	0.00641 M HCO <sub>3</sub> <sup>-</sup>	0.00389 M H <sup>+</sup>
2.3	8.5	<u>19.7</u>	21.8
57.2	65.8	70.5	82.5
			34.3
			42.3
			91.4
			103.2

- \*\* 10. (6 pts) Circle all of the following substances which have
- $\Delta G_f^\circ = 0$
- .

I<sub>2</sub>(g)Cl<sup>-</sup>(aq)Al(s)Ne(g)Br<sub>2</sub>(g)

C(diamond)

11. (6 pts) Consider the following equilibrium, for which
- $K = 17.5$
- at 298.15 K.

The reaction begins with all reactants and products at standard conditions. Circle the pressure (in atm) of N<sub>2</sub>O at equilibrium.

0.0873	0.0906	0.102	0.271	<u>0.386</u>	0.440
0.560	0.614	0.729	0.898	0.909	1.08