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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 Every reaction with a positive ΔS_{sys} is allowed.

F $S°$ of $SF_4(g)$ is greater than $S°$ of $SF_6(g)$.

T ΔG_f° for $O_2(g)$ is zero.

T The direction of allowed, net change is always towards equilibrium.

T The units of k for a second order rate law are $(\text{conc}^{-1} \cdot t^{-1})$.

F For any elementary step, $E_{a,fwd} = -E_{a,rev}$.

F Increasing T increases $t_{1/2}$.

T A catalyst does not change $\Delta H°_{rxn}$.

F For any given reaction with $Q > K$, the exergonic direction is forward.

T Whenever $\Delta G°$ is zero, then K is one.

2. (6 pts) Consider the following formation equations with their equilibrium constants at 298.15 K.

$$1/2\ N_2(g) + 1/2\ O_2(g) \rightarrow NO(g) \qquad K = 6.7 \times 10^{-16}$$

$$1/2\ O_2(g) + Cl_2(g) \rightarrow Cl_2O(g) \qquad K = 9.8 \times 10^{-18}$$

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

$$N_2(g) + 2\ Cl_2O(g) \rightarrow 2\ NO(g) + 2\ Cl_2(g)$$

37 68 91 240 630 980

1,300 2,900 3,100 **(4,700)** 5,200 6,700

** 3. (6 pts) Consider the following equilibrium system.

$$2\ ClNO(g) \rightleftharpoons 2\ NO(g) + Cl_2(g)$$

The following conditions were measured at equilibrium.

1.11 atm ClNO 0.0051 atm NO 0.0031 atm Cl_2

Circle the value for K.

1.9×10^{-8} 4.2×10^{-8} **(6.5×10^{-8})** 3.7×10^{-7} 5.6×10^{-7} 8.4×10^{-7}

2.2×10^{-6} 5.6×10^{-6} 7.9×10^{-6} 1.3×10^{-5} 4.6×10^{-5} 7.9×10^{-5}

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4. (6 pts) Give the sign of $\Delta S°$ for each of the following processes.

Combustion reaction of $CS_2(g)$ to $CO_2(g)$ and $SO_2(g)$	−
Formation reaction for $H_2O(l)$	−
Lattice energy equation for NaCl(s)	+

5. (10 pts) The following equation is balanced.

$$2\ H_2S(aq) + SO_2(aq) \rightarrow 3\ S(s) + 2\ H_2O(l)$$

Circle the value of $\Delta G°$ in kJ.

–81.67	–87.20	–91.59	–96.06	–102.22	–109.54
–115.42	**–117.94**	–122.51	–127.64	–133.08	–136.89

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

0.0652 M H_2S	0.560 M SO_2	2.45 mol S	500. g H_2O		
–76.6	–79.3	–87.2	–89.5	–100.4	**–102.9**
–112.6	–118.1	–121.9	–129.5	–130.4	–137.5

6. (8 pts) The following is an elementary step.

$$2\ NO(g) \rightarrow N_2(g) + O_2(g)$$

Write the rate law. $k[NO]^2$

What is the molecularity of the step? 2

Is the step exothermic or endothermic? exo

** 7. (6 pts) The equilibrium vapor pressure of water at 50.00 °C is 92.6 Torr. Circle the value of $\Delta G°_{vap}$ (in kJ) at this temperature.

3.40	3.68	4.05	4.58	5.32	**5.66**
6.18	6.72	7.49	7.97	8.15	8.43

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** 8. (6 pts) Write the Q expression for the following equation.

$$MgCO_3(s) + 2\,H^+(aq) \rightleftharpoons Mg^{2+}(aq) + CO_2(g) + H_2O(l)$$

$$\frac{[Mg^{2+}]\,P_{CO_2}}{[H^+]^2}$$

** 9. (10 pts) The following reaction is second order in NO_2; $k = 0.68$ (L/mol)/s^{-1} at 500 K.

$$2\,NO_2(g) \rightarrow NO(g) + NO_3(g)$$

The reaction begins with $[NO_2] = 0.0341$ mol/L. Circle the concentration (in mol/L) of NO_2 which remains after 30. s.

0.010	0.012	(0.014)	0.016	0.018	0.020
0.022	0.024	0.026	0.028	0.030	0.032

Circle the percent completion after 30. s. (Above answer must be correct for credit here.)

4.8%	7.0%	13%	19%	24%	30.%
36%	42%	48%	53%	(59%)	65%

** 10. (6 pts) Circle the change in free energy (in kJ) at standard conditions for the combustion of 7.94 g $H_2(g)$ to form $H_2O(l)$.

–101	–180.	–265	–344	–422	–509
–588	–667	–745	–821	(–934)	–985

11. (6 pts) Consider the following equilibrium system, for which $K = 0.0222$ at 298.15 K.

$$CH_4(g) + C_3H_8(g) \rightleftharpoons 2\,C_2H_6(g)$$

The reaction begins with all reactants and product at standard conditions. Circle the pressure (in atm) of C_2H_6 at equilibrium.

0.0810	0.0962	0.113	(0.208)	0.396	0.407
0.593	0.656	0.751	0.887	0.904	1.01