Chemistry 431
Practice Final Exam
Fall 2023
2 Hours

R =8.3144 J mol^{-1} K^{-1}

R=.0821 L atm mol^{-1} K^{-1}

R=.08314 L bar mol^{-1} K^{-1}

k=1.381 $\times 10^{-23}$ J molecule^{-1}K^{-1}

h=6.626 $\times 10^{-34}$ Js

N_A = 6.022 $\times$ 10^{23} molecules mol^{-1}

F=96485 C mol^{-1}

g=9.8 m s^{-2}

1 atmosphere = 1.01 bar = 1.01 $\times 10^5$ N m^{-2}

1 kg = 1000. g

1 L = 10^3 cm^3

10^2 cm = 1 m

$\sigma = 4\pi r^2 \qquad V = (4/3)\pi r^3$

$T = t + 273.15$

$1 + x + x^2 + x^3 + \ldots = 1/(1-x) \qquad |x| < 1$

Each question is worth 33 Points. Writing your correct name on the cover and on all pages with work is worth 2 points.

Name:

1. Calculate $q, w, \Delta U, \Delta H$ and ΔS when 3.50 moles of an ideal monatomic gas initially at a temperature of $T_i = 298$ K and a pressure of $P_i = 1.00$ bar are taken though the following two-step process: 1) the gas is compressed adiabatically and reversibly until the volume is 0.750 times the initial volume, and 2) the gas expands adiabatically against a constant external pressure of 1.00 bar until equilibrium is reached.

Name:

2. Show that

$$\left(\frac{\partial U}{\partial T}\right)_S = \frac{C_V P}{T(\partial P/\partial T)_V}$$

and evaluate the expression for an ideal monatomic gas.

Name:

Name:

3. Solid sulfur occurs in two crystalline forms, rhombic and monoclinic. The solubility of rhombic sulfur in $CCl_{4(\ell)}$ is 0.262 molal at 298K. Given $\Delta_{r,m}G^{\ominus}$ for the reaction

$$S_{rhombic} \longrightarrow S_{monoclinic}$$

is 96.1 J mol^{-1} at 298 K, calculate the molal solubility of monoclinic sulfur in carbon tetrachloride at 298K. You should assume both solutions are sufficiently dilute that the solutes obey Henry's law.

Name:

4. At a total pressure of 4.00 bar, it is found that the degree of dissociation α for the gas-phase process

$$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$$

is 0.140 at 298K and 0.200 at 308K. Assuming the standard enthalpy change for the reaction is temperature independent, calculate $\Delta_{r,m}H^{\ominus}$, $\Delta_{r,m}U$, $\Delta_{r,m}G^{\ominus}$ and $\Delta_{r,m}S^{\ominus}$ for the reaction at 298K.

Name:

Name:

5. At 298K the EMF of the cell

$$\mathrm{Cd}_{(s)}|\mathrm{CdSO}_{4(s)}|\mathrm{SO}^{2-}_{4(aq)}(a=0.753)||\mathrm{Cl}^{-}_{(aq)}(a=0.215)|\mathrm{Cl}_{2(g)}(P/P^{\circ}=2.50)|\mathrm{Pt}_{(s)}$$

is 1.652 V. Given the half-cell potentials of the chlorine and cadmium sulfate electrodes to be respectively $E^{\circ}_{Cl^-/Cl_2/Pt} = 1.35827$ V and $E^{\circ}_{SO_4^{2-}/CdSO_4/Cd}$=-0.246 V, calculate the fugacity coefficient of the chlorine gas in the cell.

Name:

6. The enthalpy of vaporization of rubbing alcohol (liquid isopropan-2-ol, $CH_3CHOHCH_3$) is $\Delta_{vap,m}H = 44.0$ kJ mol^{-1}, and the vapor pressure of rubbing alcohol is 5.79 $\times 10^{-2}$ bar at 296 K. A 10.00 L tank fitted with a frictionless piston contains excess liquid rubbing alcohol in equilibrium with its vapor, and the assembly is immersed in a heat bath at a fixed temperature of 308 K. The piston is compressed isothermally against a constant external pressure of 1.00 bar to a final volume of 5.00 L. Calculate $q, w, \Delta U, \Delta H, \Delta S$ and ΔG for the compression process.

Name:

Periodic Table of the Elements

	1 (1A)												13 (3A)	14 (4A)	15 (5A)	16 (6A)	17 (7A)	18 (8A)
1	1 H 1.0079	2 (2A)																2 He 4.0026
2	3 Li 6.941	4 Be 9.01218											5 B 10.811	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.1797
3	11 Na 22.9898	12 Mg 24.305	3 (3B)	4 (4B)	5 (5B)	6 (6B)	7 (7B)	8 (8B)	9 (8B)	10 (8B)	11 (1B)	12 (2B)	13 Al 26.9815	14 Si 28.0855	15 P 30.9738	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
4	19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.88	23 V 50.9415	24 Cr 51.9961	25 Mn 54.9381	26 Fe 55.847	27 Co 58.9322	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
5	37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.224	41 Nb 92.9064	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.42	47 Ag 107.868	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.76	52 Te 127.60	53 I 126.904	54 Xe 131.29
6	55 Cs 132.905	56 Ba 137.327	57 La 138.906	72 Hf 178.49	73 Ta 180.948	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra 226.025	89 Ac 227.028	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 Ds (281)	111 Rg (272)	112 Uub (285)	113 Uut (284)	114 Uuq (289)	115 Uup (288)	116 Uuh (292)	117 Uus ?	118 Uuo (294)

58 Ce 140.115	59 Pr 140.908	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 152.965	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.967
90 Th 232.038	91 Pa 231.036	92 U 238.029	93 Np 237.048	94 Pu (240)	95 Am (243)	96 Cm (247)	97 Bk (248)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

Scratch

Scratch

Scratch

Scratch

Scratch

Scratch