

CHEMISTRY 104
Hour Exam I
Summer 2025

Name _____

Free Response Questions

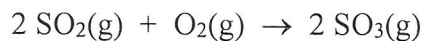
GRADING: MC _____ (81)
28. _____ (12)
29. _____ (7)
30. _____ (8)
31. _____ (6)
32. _____ (8)
33. _____ (9)

Total _____ **131**

For best results please don't leave blanks on the objective or written-out problems.
Please show all steps or logic on the written problems so partial credit can be awarded.

WRITTEN OUT PROBLEMS – Show all work for partial credit.

28. Consider the following reaction and data:
(12 pts.)



Compound	ΔH_f°	S°
$\text{SO}_3(\text{g})$	-396 kJ/mol	257 J/K•mol
$\text{SO}_2(\text{g})$	-297 kJ/mol	248 J/K•mol
$\text{O}_2(\text{g})$	?	205 J/K•mol

- a) Calculate the value of ΔG° for the reaction at 25°C.
- b) Assuming ΔH° and ΔS° are temperature independent, calculate the temperatures at which this reaction is spontaneous (assuming all gases are at 1 atm).
- c) At standard conditions, this reaction is allowed to react to reach equilibrium. If, at equilibrium, the partial pressures of $\text{O}_2(\text{g})$ and $\text{SO}_3(\text{g})$ are 0.50 atm and 2.0 atm respectively, calculate the equilibrium partial pressure of $\text{SO}_2(\text{g})$. Note: $T = 25^\circ\text{C}$

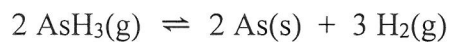
29. Consider the following equilibrium constant vs. temperature data for some reaction:
(7 pts)

K	Temp
2.54×10^4	109°C
5.04×10^2	225°C
6.33×10^1	303°C
2.25×10^{-1}	412°C
3.03×10^{-3}	539°C

a) Is this reaction spontaneous at standard concentrations and $T = 25^\circ\text{C}$? Explain.

b) Predict the signs of ΔH° and ΔS° for the reaction. Explain.

30. The gas arsine, AsH_3 , decomposes by the following reaction:
(8 pts)



In an experiment, pure $\text{AsH}_3(\text{g})$ of unknown initial concentration is placed into a 2.0 L container. After equilibrium is reached, 6.0 moles of $\text{H}_2(\text{g})$ is produced and 12.0 moles of $\text{AsH}_3(\text{g})$ is also present. Determine the initial concentration of $\text{AsH}_3(\text{g})$ before the reaction took place ($[\text{AsH}_3]_{\text{initial}} = ?$). Also, calculate the value of the equilibrium constant for this reaction ($K = ?$). Show all work for credit.

31. A 0.10 *M* solution of the salt NaX has a pH of 11.50. Calculate the pH of a 1.0 *M* solution of HX.
(6 pts)

32. Consider 1.0 L of a solution composed of 1.60 *M* HONH₂ ($K_b = 1.1 \times 10^{-8}$) and 0.80 *M* HONH₃NO₃.

(8 pts)

a) Calculate the pH of this solution.

b) In order for this 1.0 L of solution to have $\text{pH} = \text{pK}_a$, would you add HCl or KOH? What quantity (moles) of HCl or KOH would you add to the solution to get $\text{pH} = \text{pK}_a$?

33. Consider the titration of 200.0 mL of 0.10 *M* HNO₃ titrated by 0.10 *M* Ca(OH)₂. Sketch the titration curve for this titration. On your plot, label the axis and indicate the pH and volume of the equivalence point. Also indicate the initial pH before any Ca(OH)₂ has been added as well as the pH at 150.0 mL of Ca(OH)₂ added.

(9 pts)