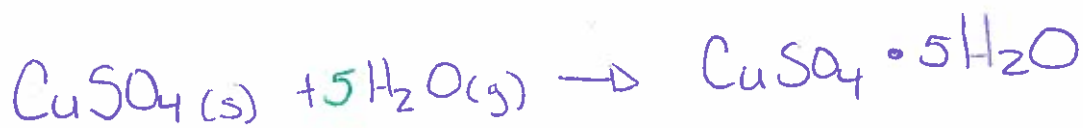


1. Solid copper (II) sulfate reacts with water vapour to produce solid copper (II) sulfate pentahydrate. Write the chemical equation that represents the reversible reaction.

/2



2. Predict whether the following equilibria favour reactant formation, product formation, or neither.

Reaction	What is favoured?
$\text{PCl}_5(\text{g}) \leftrightarrow \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$ $K = 0.45$	Reactants
$\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \leftrightarrow 2\text{HCl}(\text{g})$ $K = 1.0$	Neither
$\text{I}_2(\text{g}) + \text{Cl}_2(\text{g}) \leftrightarrow 2\text{ICl}(\text{g})$ $K = 2.0 \times 10^6$	Products

/3

3. Write chemical equation for the following:

- a. Methane gas reacts with hydrogen sulfide gas to produce carbon disulfide gas and hydrogen gas.

/2



- b. Hydrogen sulfide gas combusts in air to produce solid sulfur and water vapour.

/2



- c. Solid silicon dioxide reacts with hydrogen fluoride gas to produce silicon tetrafluoride and water vapour.

/2



4. For each of 3 a), b), and c) above, write the equilibrium expression. (/6)

a.

$$K = \frac{[\text{CS}_2][\text{H}_2]^4}{[\text{CH}_4][\text{H}_2\text{S}]^2}$$

b.

$$K = \frac{[\text{H}_2\text{O}]^8}{[\text{H}_2\text{S}]^8 + [\text{O}_2]^4}$$

c.

$$K = \frac{[\text{H}_2\text{O}]^2}{[\text{HF}]^4}$$

2. Rank the acids below in terms of their strength. Justify your choices.

Chemical formula	Name	K_a	
$\text{HNO}_2(\text{aq})$	nitrous acid	4.8×10^{-4}	2
$\text{HNO}_3(\text{aq})$	nitric acid	very high	1
$\text{HC}_2\text{H}_3\text{O}_2(\text{aq})$	acetic acid	1.8×10^{-5}	3

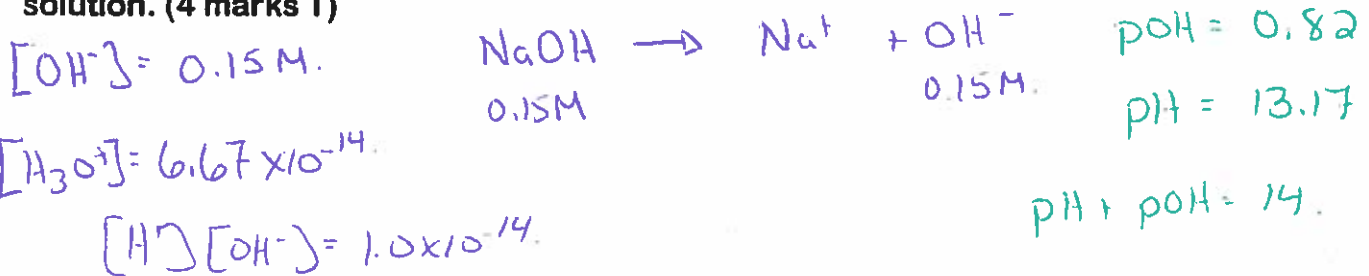
12.

13. Rank: (3 marks K)

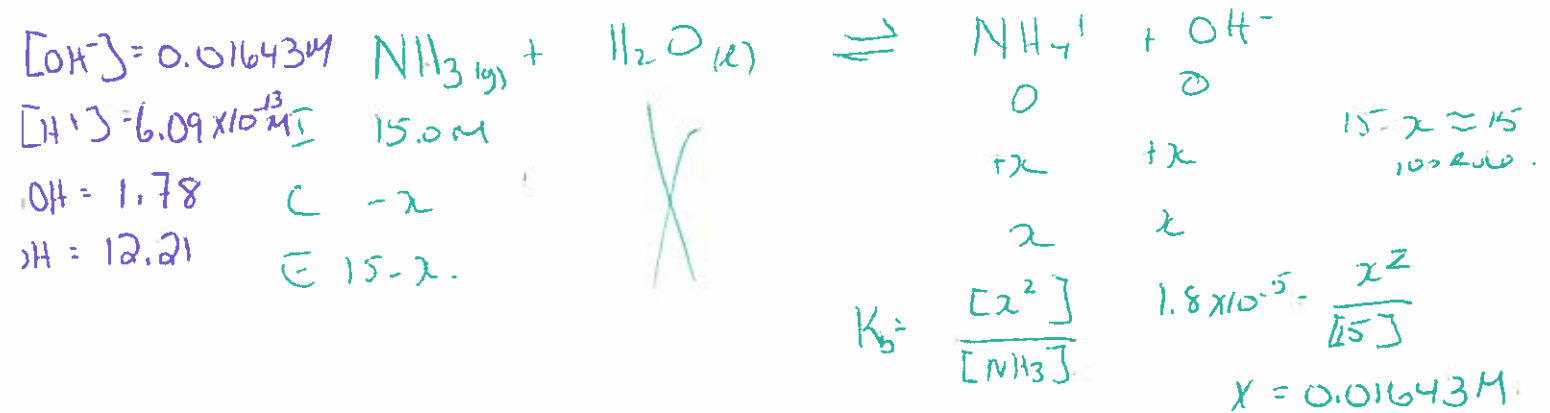
#1 $\text{HNO}_3(\text{aq})$	#2 $\text{HNO}_2(\text{aq})$	#3 $\text{HC}_2\text{H}_3\text{O}_2(\text{aq})$
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Why? (2 marks T)

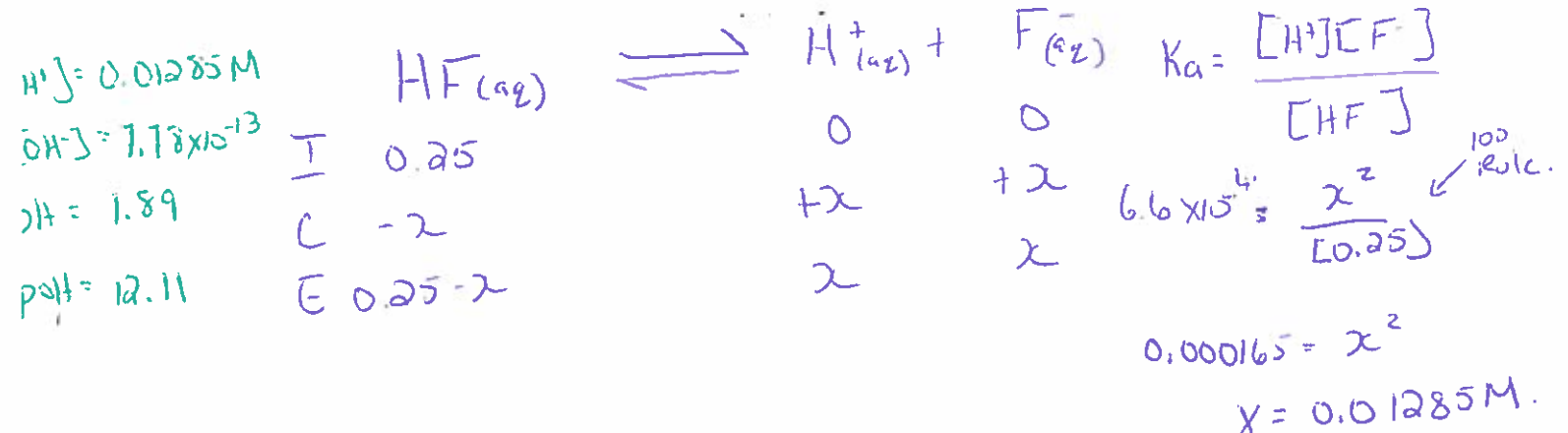
4. Determine the concentration of H_3O^+ and OH^- ions, pH, and pOH for a 0.15 mol/L NaOH solution. (4 marks T)



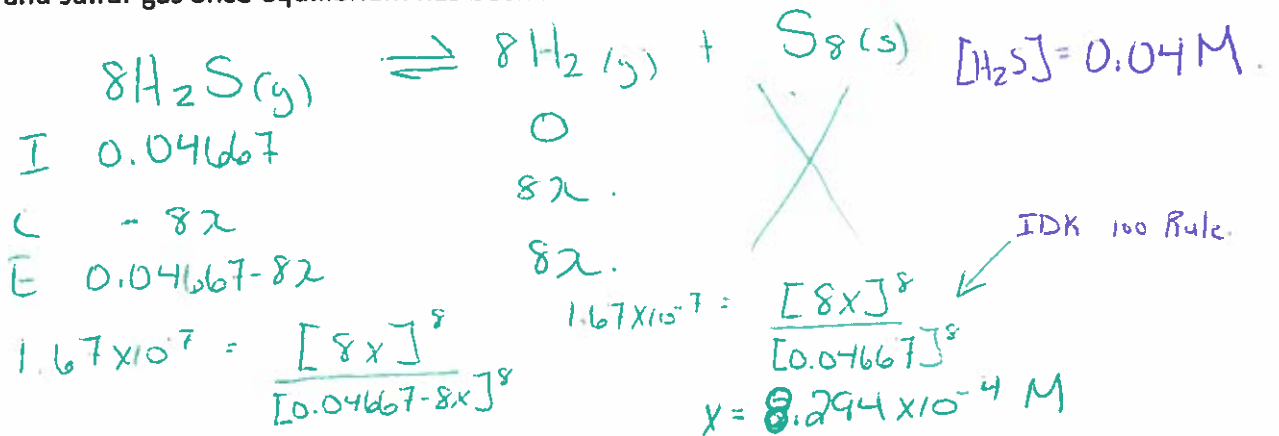
5. Determine the pH, pOH, $[\text{H}^+]$ and $[\text{OH}^-]$ of a 15.0 mol/L solution of NH_3 . (4 marks T)



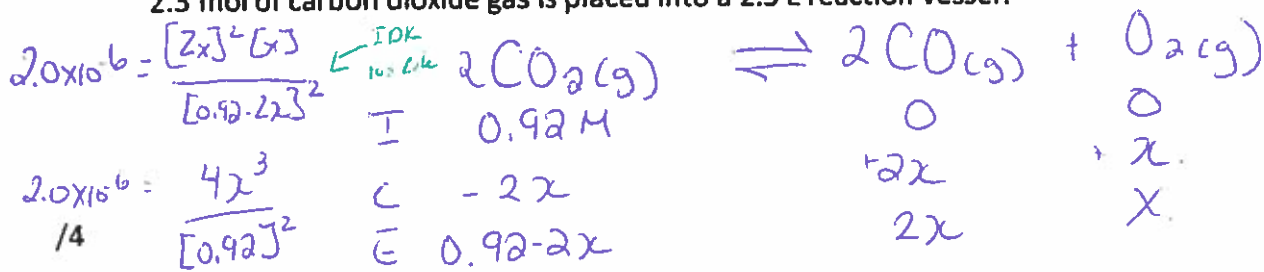
6. Calculate the pH, pOH, $[\text{H}^+]$ and $[\text{OH}^-]$ of a 0.25 mol/L solution of HF. (4 marks T)



3. Hydrogen sulfide gas decomposes into its elements. If $K = 1.67 \times 10^{-7}$, at a constant temperature and 0.035 mol of hydrogen sulfide gas is placed in a 0.75 L flask, what will be the concentrations of hydrogen and sulfur gas once equilibrium has been reached?



9. Given that $K = 2.0 \times 10^{-6}$ for the following reaction, what is the equilibrium concentration of $\text{CO}(g)$ if 2.3 mol of carbon dioxide gas is placed into a 2.5 L reaction vessel?

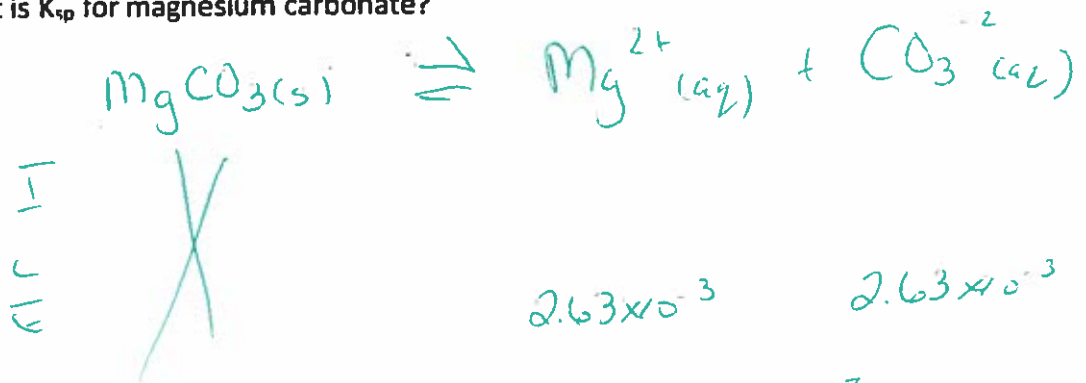


$x = 0.0075 \text{ M}$

$[\text{CO}] = 0.015 \text{ M}$

10. A student determines that the solubility of magnesium carbonate solid in water at a certain temperature is $2.63 \times 10^{-3} \text{ mol/L}$.

- a. What is K_{sp} for magnesium carbonate?



$K_{sp} = [\text{Mg}^{2+}] [\text{CO}_3^{2-}]$

$$K_{sp} = [2.63 \times 10^{-3}]^2$$

$$= 6.92 \times 10^{-6}$$

5. The Haber process generates ammonia, which is used to make a number of important products, including fertilizer. Using the following chemical equation representing the Haber process, complete the chart below:



Change	System Shift	Effect on K
[NH ₃] decreased	Right →	↑
[H ₂] decreased	Left ←	↓
Pressure decreased	Left ←	↓
Volume decreased	Right →	↑
Temperature increased	Left ←	↓
Addition of argon gas	No shift	none.

/12

6. At equilibrium in a reaction vessel, the concentrations of O_{2(g)} and N_{2(g)} are 4.3 mol/L. Given the following equation, determine the concentration of NO_(g).



$$K_{\text{eq}} = 6.3 \times 10^{-4}$$

$$K = \frac{[\text{NO}]^2}{[\text{O}_2][\text{N}_2]}$$

$$6.3 \times 10^{-4} = \frac{[\text{NO}]^2}{[4.3][4.3]}$$

$$[\text{NO}] = 0.108 \text{ M}$$

/4

7. Into a 2.00 L vessel is placed 0.600 mol of methane gas. The following reaction proceeds:



At equilibrium, the vessel is found to contain 0.0900 mol C₂H₄. Calculate the equilibrium constant for this reaction.

I	0.3	0	0
C	-2x	+x	+3x
E	0.3-2x	x	3x
	0.21	0.045M	0.135

$$K = \frac{[\text{C}_2\text{H}_4][\text{H}_2]^3}{[\text{CH}_4]^2}$$

$$K = \frac{[0.045][0.135]^3}{[0.21]^2}$$

$$K = 2.51 \times 10^{-3}$$

/4