

10.420/10.520

Problem Set #1

Short Answer questions:

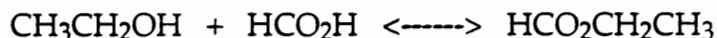
1. The free radical chlorination of methane produces a variety of products: carbon tetrachloride (CCl_4), chloroform (CHCl_3), dichloromethane (CH_2Cl_2), chloromethane (CH_3Cl), and unreacted methane (CH_4).
- a) If the mixture were fractionally distilled, predict the order that the compounds would be collected as distillates. Explain your reasoning in one sentence.
- b) As solvents, which compounds is the most polar? the most nonpolar?

2. Methanol exist in equilibrium with dimethyl ether and water.



Using only your chemical intuition, explain which of the three compounds is likely to have the highest and lowest boiling points.

3. Ethanol and formic acid exist in equilibrium with ethyl formate.



Using only your chemical intuition, explain which of the three compounds is likely to have the highest and lowest boiling points.

4. a) Hydrogen sulfide (H_2S : MW = 34; boiling point = -60°C) is a gas at room temperature while water (H_2O : MW = 18; boiling point = 100°C) is a liquid. Provide a one sentence explanation.
- b) Ammonia (NH_3 : MW = 17; boiling point = -33°C) is a gas at room temperature while water (H_2O : MW = 18; boiling point = 100°C) is a liquid. Provide a one sentence explanation.
5. Acetone (CH_3COCH_3), butane ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$), and nitromethane (CH_3NO_2) have similar molecular weights (MW = 58-61) but boiling points that differ by $>100^\circ\text{C}$. Using your chemical intuition, assign the highest and lowest boiling compounds and provide a brief explanation.
6. Succinonitrile ($\text{NC}(\text{CH}_2)_2\text{CN}$; MW = 80) and malononitrile (NCCH_2CN ; MW = 66) have boiling points that are $\sim 200^\circ\text{C}$ higher than hexane ($\text{CH}_3(\text{CH}_2)_4\text{CH}_3$; MW = 86) and pentane ($\text{CH}_3(\text{CH}_2)_3\text{CH}_3$; MW = 72), respectively.
- a) Explain why these substitutions are responsible for the dramatic increases in boiling point.
- In contrast with the above comparison, cyanogen (NCCN ; MW = 52) has a boiling point that is $>20^\circ\text{C}$ LOWER than butane ($\text{CH}_3(\text{CH}_2)_2\text{CH}_3$; MW = 58).
- b) Provide an explanation for this difference that is compatible with your answer to part (a).