Exercise 12.2
K_a, pK_a, K_b and pK_a

1. In a conjugate acid-base pair, the K_a of the conjugate acid and the K_b of the conjugate base are related by the formula $K_a \cdot K_b = K_w$.

   K_w varies with temperature. At 25°C, $K_w = 10^{-14}$.

(a) Recognizing that $pAnything = -log(Anything)$, use log rules to demonstrate that $pK_a + pK_b = pK_w$ and that, at 25°C, $pK_a + pK_b = 14$.

(b) Formic acid has a pK_a value of 3.74. Calculate the K_a value for formic acid.

(c) Formic acid (HCO_2H) is a carboxylic acid with one hydrogen atom attached to the carbon atom. Draw both formic acid and its conjugate base.

(d) The conjugate base of formic acid is called formate. Calculate the K_b and pK_b of formate at 25°C,. Label each of your structures in part (c) with the appropriate values for K_a, pK_a, K_b or pK_b at 25°C,. Please note that you do not have sufficient information to calculate all four values for each species.

2. Both K_a and pK_a values can be used to compare strength of acids. To emphasize the difference between how these two scales work, complete the following table.

Relative Strength	$\boldsymbol{pK_a}$	$\boldsymbol{K_a}$	**Acid**
Strong		1×10^7 $(10{,}000{,}000)$	
Border between strong and weak	0		
Weak	2.1		
Very weak		1×10^{-14} (0.00000000000001)	
So weak we don't call it an acid		1×10^{-48}	

For the "acid" column, choose between the following chemical formulas:

$$CH_4, HCl, H_2O, H_3O^+, H_3PO_4$$

It's fine to write the remaining K_a values using scientific notation. The expansion of two K_a values was to emphasize whether K_a was getting larger or smaller. The last K_a value would have 48 zeroes in front of the 1; that was too many to fit in the table!

3.

(a) Briefly explain how you could use either pK_a values or K_a values to determine which is a stronger acid between CH_3CH_2SH and CH_3CH_2OH.

(b) Briefly explain how you could use either pK_a values or K_a values to determine which is a stronger base between CH_3CH_2SH and CH_3CH_2OH.