Name ____ CHM 1045
Spring 2018
February 28

EXAMINATION TWO

_______ I _______ II _______ III _______ IV _______ V _______ Total __________

This exam consists of several problems. Rough point values are given. The total will be scaled to 100 points after the exams are marked. For questions with multiple parts, you do not necessarily need the answer to Part A in order to work Part B, Part B to Part C, etc. If you do need a previous answer, the next question will be marked assuming the previous question is correct; however, if you were unable to answer the previous part, make up a reasonable answer and use that for subsequent calculations. Glance over the entire exam, and then attempt the problems in the order of your choice. For calculations, give your answer to the correct number of ***significant figures***, and be sure to include the ***correct units*** for your answer. ***You must show your work to receive any credit for a calculated answer.*** Additional information is provided in a separate information packet; you can use the back for scratch work.

(2 points) Circle the recitation section you are attending.

Chengqi Zhang	Dallas Mann	Matt Donohue
22, 2:00-2:50 pm, HTL 213	25, 2:00-2:50 pm, HTL 214	28, 1:00-1:50 pm, HTL 219
23, 3:00-3:50 pm, HTL 213	26, 3:00-3:50 pm, HTL 214	29, 2:00-2:50 pm, HTL 219
24, 4:00-4:50 pm, HTL 213	27, 4:00-4:50 pm, HTL 214	30, 3:00-3:50 pm, HTL 219

I. (12 points) Write balanced molecular equations (ME) and net ionic equations (NIE) for the following reactions. *Be sure to include the correct states in your final equations and charges for ions in the NIE.*

A. $HNO_3(aq) + KNO_2(aq) \rightarrow$

ME:

NIE:

B. $Na_2SO_4(aq) + AgNO_3(aq) \rightarrow$

ME:

NIE:

II. (14 points) Balance the following chemical equations:

A. $Fe_2O_3 + CO \rightarrow Fe + CO_2$

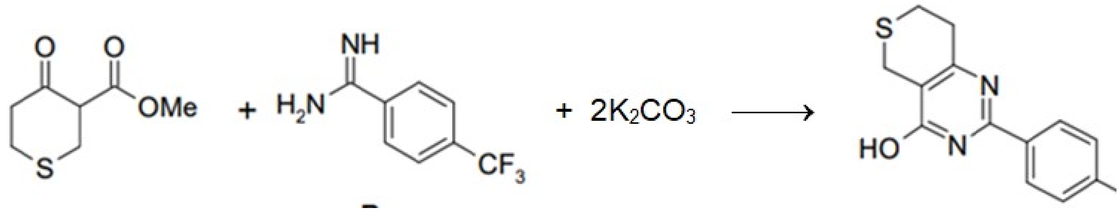
B. $SF_4 + H_2O \rightarrow H_2SO_3 + HF$

Now name the two acids produced in the above reactions.

H_2SO_3 ____________________________ acid

HF ____________________________ acid

III. (30 points) Tankyrases (TNKSs) are enzymes that catalyze (increase the rate) of some protein reactions. Several studies have shown that TNKSs may serve as anti-cancer drugs; see *Scientific Reports*, **2018**, *8*, 1-10. The synthesis of one of the first TNKSs to show potential as an anti-cancer drug, NVP-XAV939, is shown below (*Nature*, **2009**, *461*, 614–620).



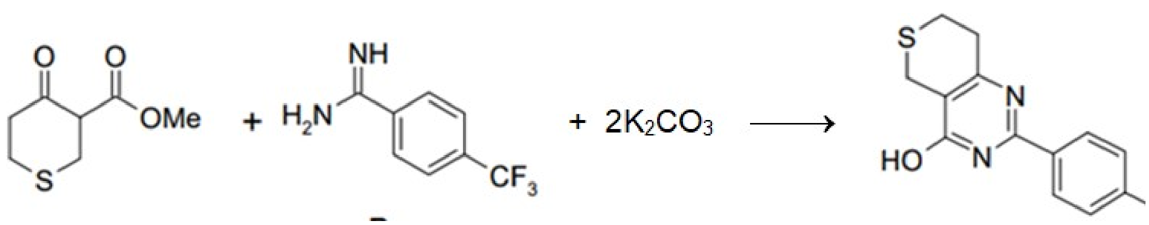
A. NVP-XAV939 was synthesized by reacting 0.876 g of A with 1.42 g of B. Which of these reactants is the limiting reagent?

Compound	molar mass
A	172.22 g/mol
B	176.14 g/mol
K_2CO_3	138.21 g/mol
NVP-XAV939	300.30 g/mol

B. Assuming the reaction goes to completion, what would be the yield of NVP-XAV939 in grams?

C. After purification and drying, 1.24 g of NVP-XAV939 was obtained. What was the percent yield for this reaction?

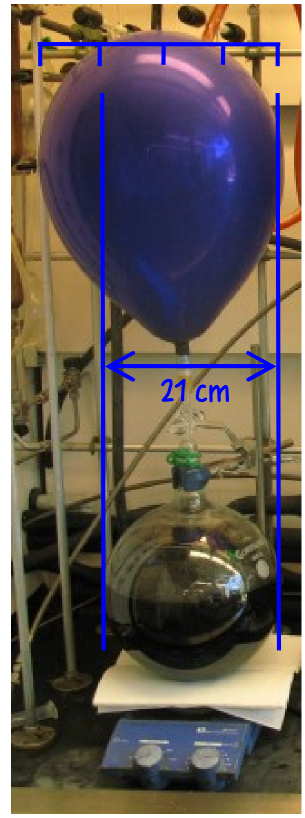
D. Taking another look at the reaction we see that K_2CO_3 is also required.



1. Is K_2CO_3 acidic or basic? Explain your reasoning.

2. What mass of K_2CO_3 is required for the reaction based on the information given in Part A.

IV. (24 points) Another important reaction in organic synthesis, polymers, and the food industry is hydrogenation. These reactions are typically carried out in "generators" at temperatures and pressures higher than ambient conditions. Sometimes, however, you can get away with milder conditions using a balloon generator, as shown in the image on the right. The balloon is filled with the desired amount of H_2 gas (often determined by a stoichiometric calculation), and then attached to a flask containing the reaction mixture.



A. Calculate the moles of $H_2(g)$ contained in the balloon on the right. We can assume they used dry hydrogen, so we do not need to correct for water vapor. The temperature in the lab is 24.5°C. The pressure inside the inflated balloon was measured to be 15 mmHg gauge pressure. Based on the 5 L round bottom flask in the photo, we can estimate the volume of the balloon to be around 11 L.

B. You can also hydrogenate with deuterium, $D_2(g)$, where deuterium is the isotope of hydrogen with one neutron in the nucleus. So the mass of a D atom would be roughly 2 amu, and the molar mass of D_2 would be 4 g/mol.

Assuming you did everything else just the same, which balloon...

1. is heavier? H_2 D_2 they're both the same
2. contains the most gas molecules? H_2 D_2 they're both the same
3. contains molecules with the higher average kinetic energy? H_2 D_2 they're both the same

D. Do you expect a $D_2(g)$ filled balloon to float in air? _______________

Explain.

V. (14 points) A recent eye-catching article from ScienceDaily, ***Turning Beer into Fuel****, was actually about the use of alcohols as fuels (*www.sciencedaily.com/releases/2017/12/171206100119.htm). The paper states that compared to ethanol, "a much better fuel alternative is butanol but this is difficult to make from sustainable sources"; however, the article does not say why butanol is better. I found this...

> ***In other words, methanol and ethanol are not great fuel sources because they produce more carbon dioxide than their equivalent hydrocarbons for the same amount of energy. ... Butanol produces LESS carbon dioxide than gasoline for the same amount of energy.***
>
> (biofuel.org.uk/bioalcohols.html)

Combustion of a "mole" of gasoline provides around 4800 kJ of energy and produces roughly 350 g of CO_2. Combustion of a mole of butanol provides 2724 kJ of energy.

$$C_4H_9OH(\ell) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(\ell) + 2724\ \text{kJ/mol}$$

A. How much butanol would be required to provide 4800 kJ of energy?

B. How much carbon dioxide (in g) would be produced in Part A?

C. So, does butanol produces "LESS" carbon dioxide than gasoline for the same amount of energy? Explain.