CH302 UNIT 6 EXAM
Free Response (30 pts)
Vanden Bout/LaBrake
Spring 2013

Name: _____KEY_____
UT EID: _____
Version #: _____

Questions are on front and back of this FR exam. Only responses inside the provided boxes will be graded. Show work (also inside boxes) for partial credit.

1. (13 pts total) Consider the following reaction:

$$H_2O\ (g) + CH_4\ (g) \leftrightarrow CO\ (g) + 3H_2\ (g)$$

a) (2pts) Write the equilibrium expression, K_c for this reaction.

$$K_c = \frac{[CO][H_2]^3}{[H_2O][CH_4]}$$

A perfect 2/2 if it looked like the equation above. We did not take points off if parenthesis were used instead of brackets

Then you received a score of ½ if any ONE of the following occurred (2 or more received a score of 0/2):
-1 pt for using pressures
-1 pt if not products over reactants
-1 pt if not proper exponents (and/or coefficients)

b) (2pts) For the above reaction, $K_c = 3.9 \times 10^{-27}$ at 298 K and $K_c = 3.1 \times 10^2$ at 1100 K. State whether the reaction is product favored or reactant favored at each temperature.

At 298K, the reaction is reactant favored (+1)
At 1100K, the reaction is product favored (+1)

c) (1 pt) Is the above reaction endothermic or exothermic?

Endothermic (+1)

d) (2pts) Assume you start with 1.6 M H_2O and 0.75 M CH_4. Set up a RICE table to solve for the equilibrium concentrations of all reaction species.

R	H_2O (g)	+ CH_4 (g) ↔	CO (g)	+ $3H_2$ (g)
I	1.6	0.75	0	0
C	-x	-x	+x	+3x
E	1.6-x	0.75-x	x	3x

+1 proper coefficients on "x" (as long as they WORK… can use weird algebra)
opposite signs are fine as long as reactants and products are opposite
+1 filling out concentrations properly
If box "E" was not filled, score 1/2

e) (1 pt) Plug your equilibrium concentrations (in terms of x) back into your equilibrium expression. **Do not solve for x.**

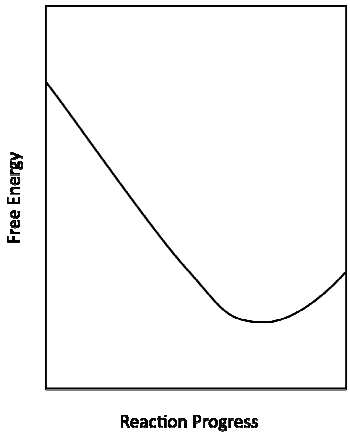
$$K_c = \frac{(x)(3x)^3}{(1.6-x)(0.75-x)} \quad \text{or} \quad K_c = \frac{27x^4}{(1.6-x)(0.75-x)}$$

This MUST be based both on Part A and Part D. Full credit will be given as long as it is clear the student used their answers from part A and D
If the EQUATION did not correlate to part A, then score 0/2

f) (2 pts) At 1100 K, can 'x' be ignored?

No, 'x' cannot be ignored. +2 "No"
(Explanation which was NOT required for full credit)
Since the K_c value is less than 10^3 away from the initial starting conditions, it cannot be ignored

g) (3 pts) For the given reaction, $K_c = 3.9 \times 10^{-27}$ at 298 K and $K_c = 3.1 \times 10^{2}$ at 1100 K. Does the reaction progress plot (on the right) correlate to the reaction at 298 K or 1100 K? Why?



This plot shows a product favored reaction
The 1100K reaction is the product favored reaction

(+1) for 1100K

(+2) for the explanation
LOTS of full and partial credit was given.
MUST comment on something about:
K>1
Product favored reaction
ΔG < 0 for spontaneous reactions (again, K>1)
Something about "the graph shows a product favored reaction"

2. (13 pts total) Consider the titration curve. The titrant is a 0.10 M solution of NaOH. The analyte is 100 mL of an unknown acid HZ.

a) (2 pt) Write the neutralization reaction that occurs.

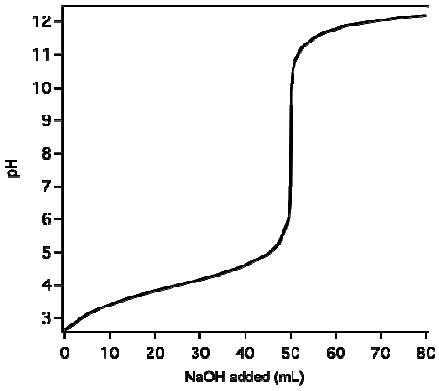
$NaOH + HZ \rightarrow Na^+ + Z^- + H_2O$

OR

$NaOH + HZ \rightarrow NaZ + H_2O$

OR

$NaOH + HZ \rightarrow ZNa + HOH$



This question has a long list of full and partial credit answers
BOTH single arrows and double arrows were accepted
Basically, a perfect equation received a score of 2/2
A good (but flawed) equation received a score of 1 out of 2
A wrong equation received a score of 0/2

b) (2 pts) Label the equivalence point and the half-equivalence point on the given curve.
(+1) for each

c) (2 pts) What is the concentration of the analyte?

$$0.1M \times 0.05L = 0.005moles$$

$$0.005moles \div 0.1L = 0.05M$$

If perfect (number and units): +2
OR partial (something is right): +1
Just a correct number WITH units receives full credit (even if no work)
Without units, -1
If they have the math set up correctly, and the answer is off by a decimal place, -1 (half credit)

Based on Part B in the case misidentified equivalence point
If used ½ equivalence point instead, ½ credit

ALSO look at Part B in the case it looks like it takes 47mL or 55mL of NaOH to reach the equivalence point

If total volume = 0.15 L, then ½ credit
If total volume = 0.05 L, then no credit

d) (2 pts) Is the unknown analyte HZ a strong acid or weak acid? What is your evidence?

(+1) Weak acid.

(+1) for explanation Multiple explanations received full credit
The space before the equivalence point is large, showing that there is a buffering region.

And/Or the equivalence point does NOT reflect a pH of 7, which is what is expected from the titration of a strong acid and a strong base

E (2pts) If the acid is a weak acid, estimate the pKa and the Ka from the data. If the acid is a strong acid, what is its approximate K_a?

pKa ~ 4 (somewhere between 3.7 and 4.3)
$K_a = 1 \times 10^{-4}$ (calculate based on the pKa)
(+1) for each
IF it was assume it was a strong acid, then the K_a ~ infinity (something VERY large)

***** For the following questions, ignore spectator ions. Choose your answer(s) from the following list:***
strong acid strong base weak acid weak base **

f) (1 pt) List the dominant species when 0 mL of NaOH has been added.

Weak acid
(+1) all or nothing
IF part D was "strong acid," full credit was given for: Strong acid

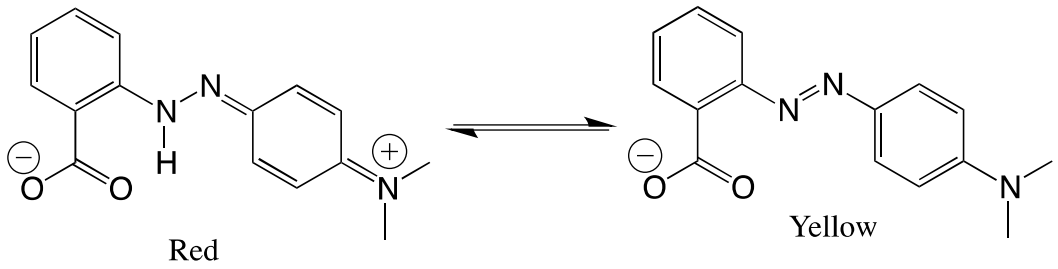
g) (1 pt) List the dominant species at the ½ equivalence point.

Equal amounts of weak acid and weak base
(+1) all or nothing
IF Part D was "strong acid," full credit was given for: Strong acid

h) (1 pt) List the dominant species at the equivalence point.

Weak base
(+1) all or nothing
IF Part D was "strong acid," full credit was given for: $[H_3O^+] = [OH^-]$ or equivalent

3. (4pts) Below is a structure of methyl red ($K_a = 7.9 \times 10^{-6}$) in both its protonated and deprotonated forms.



a) (2 pts) What will be the color of a methyl red solution with a pH of 7.9?

Yellow
(+2)
If a creative answers (yellow with a tinge of red for a burnished gold) these were accepted
Orange was NOT accepted

b) (2pts) In this solution (pH=7.9), do you expect the methyl red to be protonated or deprotonated?

Deprotonated
(+2)