Name_____
GSI _____

Chemistry 4B, Spring 2006

Midterm Exam #2
March 13, 2006
(50 min., closed book)

Name:_____ **GSI:**_____

SID:_____ **Section:**_____

Please read this first: Write your name and that of your TA on all 9 pages of the exam

Test-taking Strategy

In order to maximize your score on the exam:

- Do the questions you know how to do first.
- Go back and spend more time on the questions you find more challenging.
- Budget your time carefully -- don't spend too much time on one problem.
- Show all work for which you want credit and don't forget to include units.

Question	Page	Points	Score
Q1	3	12	
Q2	4	8	
Q3	5	10	
Q4	6	12	
Q5	7	18	
Q6	8	24	
Q7	9	16	
Total		**100**	

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$E=h\nu$

$\lambda\nu = c$

$E_{kin} = \frac{1}{2}mv^2$

$E_{kin} = 3RT/2$

$v_{rms} = \sqrt{(3RT/M)}$

$k_B = 1.381 \times 10^{-23}$ J/K

$m_{e^-} = 9.11 \times 10^{-31}$ kg

$h = 6.626 \times 10^{-34}$ J s

$c = 3.0 \times 10^{8}$ m/s

1 nm = 10^{-9} m

1 kJ = 1000 J

1 Torr = 1 mmHg

1 atm = 760 mmHg

$J = (kg\ m^2)/s^2$

$PV = nRT$

$$\left(P + a\frac{n^2}{V^2}\right)(V - nb) = nRT$$

$$\text{Potential Energy, } V(R) = 4\varepsilon\left[\left(\frac{\sigma}{R}\right)^{12} - \left(\frac{\sigma}{R}\right)^{6}\right]$$

T(K) = T(C) + 273.15

R = 0.0821 L·atm / (mol·K)

R = 8.314 J / (mol K)

$A = \varepsilon l C$

$P_a = X_a P_{tot}$

P = F/A

$N_A = 6.022 \times 10^{23}$

1 cal = 4.18 J

101.3 J = 1 L atm

$K_a K_b = K_w$

$K_w = 10^{-14}$

pX = -log X

$pK_a + pK_b = pK_w$

$$pH = pKa + \log\frac{[A^-]}{[HA]}$$

TABLE 4.3

VAN DER WAALS CONSTANTS OF SEVERAL GASES

Name	Formula	*a* (atm L^2 mol^{-2})	*b* (L mol^{-1})
Ammonia	NH_3	4.170	0.03707
Argon	Ar	1.345	0.03219
Carbon dioxide	CO_2	3.592	0.04267
Hydrogen	H_2	0.2444	0.02661
Hydrogen chloride	HCl	3.667	0.04081
Methane	CH_4	2.253	0.04278
Nitrogen	N_2	1.390	0.03913
Nitrogen dioxide	NO_2	5.284	0.04424
Oxygen	O_2	1.360	0.03183
Sulfur dioxide	SO_2	6.714	0.05636
Water	H_2O	5.464	0.03049

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1.) Gases I. Ideal and Real (12 points total)

A 1.00 mole sample of CO_2 is confined to 50mL stainless steel chamber at 25°C.

a) Calculate the pressure in the chamber if the gas behaves ideally.

b) Calculate the pressure in the chamber if the gas obeys the van der Waals equation of state.

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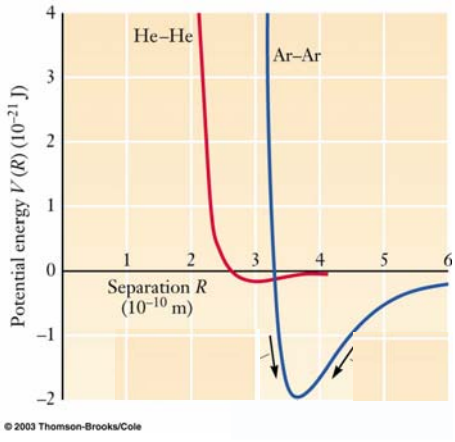
2.) Gases II. Interactions (8 points total)

The following figure is a plot of the Lennard-Jones potential for helium and argon.



a) What does the depth of the potential energy well correspond to?

The potential energy minimum for helium is at an intermolecular distance of 2.87×10^{-10} m, while the minimum for argon is 3.8×10^{-10} m.

b) Why does argon have a greater separation distance at the minimum than helium?

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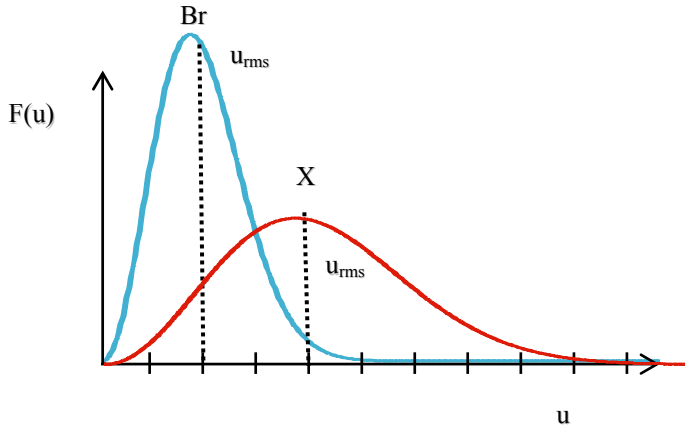
3.) Gases III (10 points total)

The Maxwell-Boltzmann distribution of speeds is shown for two gases at 300°C, Br_2 and the unknown noble gas X.



a) The root mean square average velocity for X is twice that for Br_2. What is the identity of the noble gas? (show your work)

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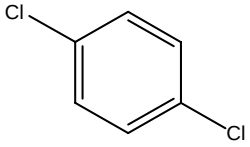
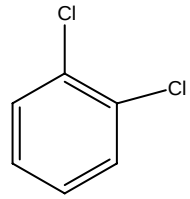
4.). Intermolecular forces (12 points total)

Circle the compound in each pair that would have the higher boiling point.	Explain your reasoning.
p-dichlorobenzene  *m*-dichlorobenzene 	
fluorine F——F bromine Br——Br	

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5.) Acids and Bases (18 points total)

Three acdis and their corresponding pKa's are shown below.

HOCl	pKa = 7.53
HOBr	pKa = 8.63
HOI	pKa = 10.64

a) Rank the acids from weakest to strongest.

< <

b) Explain your ranking based on the structures of the acids and the nature of the OH bond.

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c) What is the pH of a solution resulting from the reaction of 100mL of 0.100M NaCN and 15.00mL of 0.500M HCl? The Ka of HCN is 6.17×10^{-11} (systematic treatment of equilibrium is not required)

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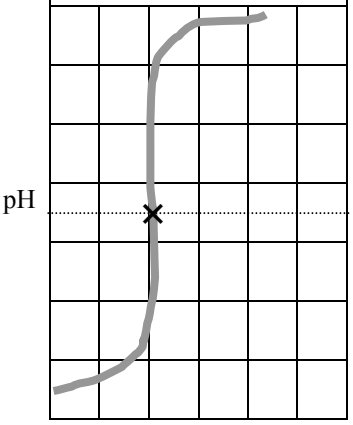
6.) Titration Curves (24 points total)

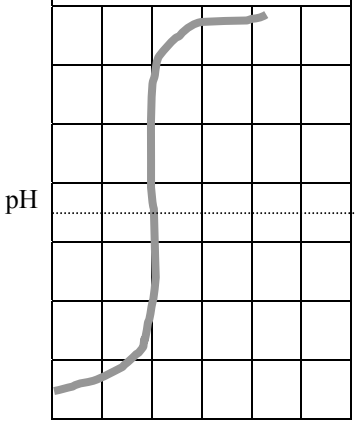
The titration of 20mL HCl with NaOH is shown for your reference in the graphs below. The dotted line indicates pH of 7. In the reference titration curves, the HCl has a concentration of 0.10M and the NaOH has a concentration of 0.10M. In each of the graphs, sketch the titration curve for the conditions specified.
Your sketches can be rough, but be sure to

- consider the initial pH
- consider the volume at the equivalence point
- mark the equivalence point with a ×
- consider the pH at the end

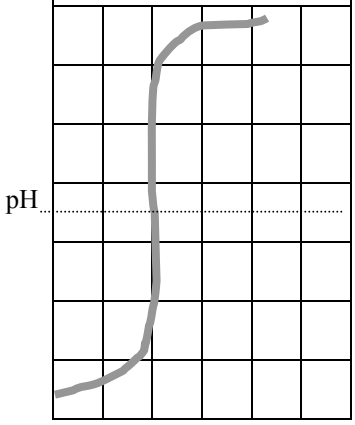
20 mL of 0.10M weak acid is titrated with 0.10M NaOH



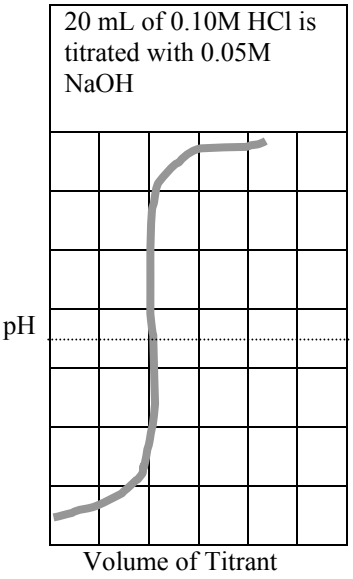
20 mL of 0.20M strong acid is titrated with 0.10M NaOH



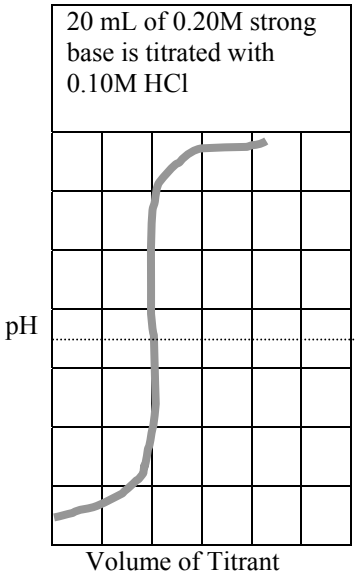
20 mL of 0.10M HCO_3^- (pKa1= 6.35, pKa2= 10.3) is titrated with 0.10M NaOH



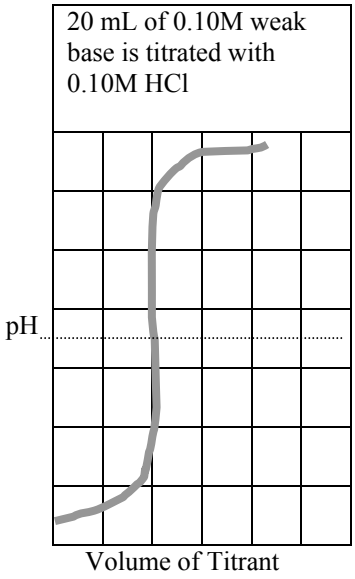
20 mL of 0.10M HCl is titrated with 0.05M NaOH



20 mL of 0.20M strong base is titrated with 0.10M HCl



20 mL of 0.10M weak base is titrated with 0.10M HCl



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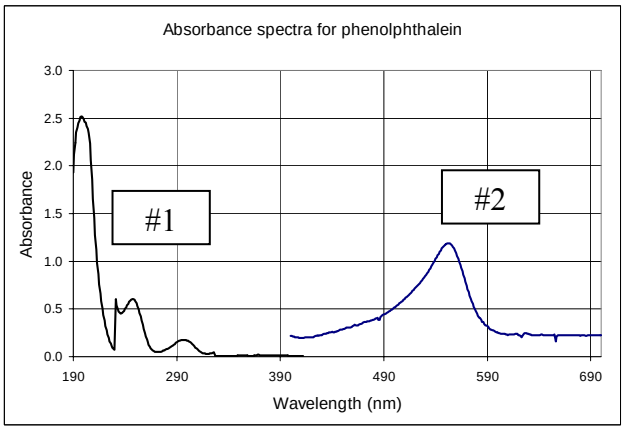
7.) Indicators (16 points total)
Phenolphthalein is an acid-base indicator that undergoes a color change when it gains or loses two protons (H^+). You have used this indicator before in lab. The two forms of the indicator are colorless and pink in solution.



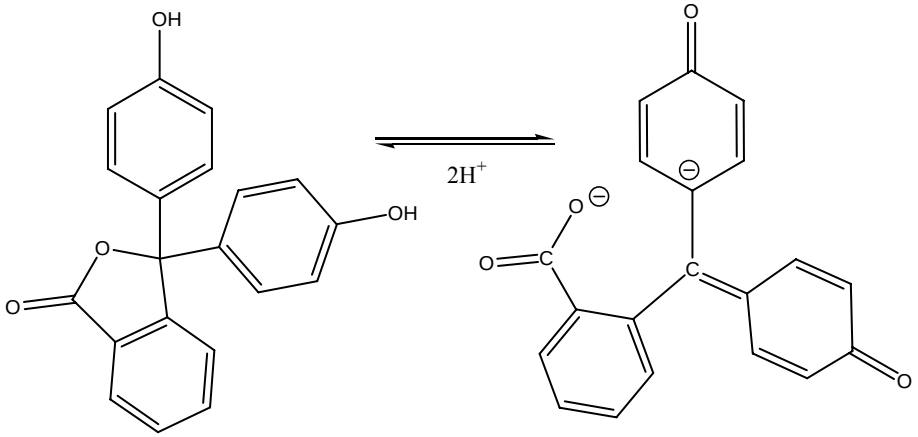
Given the absorbance spectra, which spectrum represents which molecule? (circle one)

spectrum 1 is the____solution colorless pink

spectrum 2 is the____solution colorless pink

The two molecular forms of the phenolphthalein indicator are shown below.

Molecule #1 Molecule #2



Draw an outline around the various regions of conjugated bonds on each molecule.

Which molecule corresponds to which spectrum?

Molecule # _____ corresponds to spectrum # _____.

Molecule # _____ corresponds to spectrum #_____.

Explain your reasoning in terms of conjugated bonds and the electronic transitions that occur when light interacts with the molecule.