Exam IV

CH 301H Fall '10

Vanden Bout

Name: Key

Carefully read all the problems

Show all your work on numerical problems

Clearly mark your answers

If you think a problem cannot be worked out with the information provided write "this problem can not be worked with the information provided"

Problems may contain extraneous information

Work problems you know first.
Go back to work harder problems.
Don't spend too much time on any given problem.

Please sign at the bottom to certify that you have worked on your own.

I certify that I have worked the following exam without the help of others, and that the work I am turning in is my own.

Signed: _____

Signature Date

Page 1 _____

Page 2 _____

Page 3 _____

Page 4 _____

Page 5 _____

Page 6 _____

Page 7 _____

Page 8 _____

Bonus _____

TOTAL _____

1. True/False (3 points each. 30 total)

T F The van der Waals b constant for Xe is larger than that for Ar

T F Ethers have hydrogen bonds

T F Dipole-dipole forces have a longer range than dispersion forces

T F Trifluoromethane CHF_3 has hydrogen bonds

T F For a given substance, the vapor pressure of the solid can never be higher than the vapor pressure of the liquid.

T F Sublimation in exothermic

T F At the critical temperature the liquid

T F For constant pressure, if you change the temperature of an ideal gas from 30°C to 60°C you double the volume

T F The van der Waals equation of state exactly describes the behavior of a real gas.

T F Polar liquids always have a higher boiling point than non-polar liquids

Multiple Choice (5 each. 15 total)

2. In an ideal gas there are

A. only repulsive interactions between the atoms or molecules.
B. only attractive interactions between the atoms or molecules.
C. repulsive and attractive interactions between the atoms or molecules.
D. no interactions between the atoms or molecules.
E. only repulsions and only at high temperature and pressure.

D

3. All gases will behave ideally in the limit of

A. infinitely low pressure
B. infinitely high pressure
C. infinitely low temperature
D. none of the above

A

4. If you lived in Denver where the atmospheric pressure is less than 1 atm ~~you~~

A. water would have a vapor pressure less than 1 atm at 100°C
B. water vapor would have a vapor pressure greater than 1 atm at 100°C
C. water would boil at a higher temperature
D. water would boil at low temperature

D

5. (15 total)

What type of intermolecular (interatomic) forces would you expect for the following (circle all that apply for each)

Substance				
3 SiH_4	Dispersion	Dipole-Dipole	Hydrogen Bonding	Ionic
NH_3	Dispersion	Dipole-Dipole	Hydrogen Bonding	Ionic
Xe	Dispersion	Dipole-Dipole	Hydrogen Bonding	Ionic
KF	Dispersion	Dipole-Dipole KGNaF OK	Hydrogen Bonding	Ionic
HBr	Dispersion	Dipole-Dipole	Hydrogen Bonding	Ionic

6. (15 points)
A gas obeys the following equation of state

$PV_m + \frac{\beta}{V_m} = RT$ where β is a positive constant

Are the intermolecular forces for this gas dominated by attractions or repulsions or does it depend on the temperature?

$$PV_m = RT - \frac{\beta}{V_m}$$

$$Z = \frac{PV_m}{RT} = 1 - \frac{\beta}{V_m RT}$$ always less than 1

Dominated by attractions.

(like VDW with b const = 0, & a = β)

7. (15 points)
Initially you have 1 mole of ethane in a container with 10 moles of oxygen gas. The container has a volume of 10 L and is held at a constant temperature of 400K. The mixture is sparked and reacts such that all the ethane is converted water vapor and carbon dioxide.

What is the final pressure in the container?
What are the partial pressures of all remaining gases?

$$C_2H_6 + \frac{7}{2}O_2 \longrightarrow 2CO_2 + 3H_2O$$

for each mole C_2H_6 : $\frac{7}{2}$ moles O_2

$\frac{9}{2}$ moles ⟶ 5 moles + $\frac{1}{2}$ mole gas

initially 11 moles ⟶ 11.5 moles

$$P = \frac{(11.5)(.08206)(400)}{10} = 37.75 \text{ atm} \left(38.2 \text{ bar}\right.$$

$n_{C_2H_6} = 0 \quad n_{O_2} = 6.5 \quad n_{CO_2} = 2 \quad n_{H_2O} = 3$

$P_{O_2} = \left(\frac{6.5}{11.5}\right)P = 21.3 \quad P_{CO_2} = \left(\frac{2}{11.5}\right)P = 6.6 \quad P_{H_2O} = \left(\frac{3}{11.5}\right)P = 9.8$

$P_{C_2H_6} = 0$

8. (10 points)
A mixture of gases contains 2 moles of He and 3 moles of H_2 at a fixed temperature. What is the ratio of the rms velocity of the He to the H_2?

$$v_{rms} = \sqrt{\frac{3RT}{M}} \qquad \frac{v_{He}}{v_{H_2}} = \frac{\sqrt{\frac{3RT}{M_{He}}}}{\sqrt{\frac{3RT}{M_{H_2}}}} = \sqrt{\frac{M_{H_2}}{M_{He}}} = \sqrt{\frac{2}{4}}$$

$$= \frac{1}{\sqrt{2}} = 0.7$$

9. (20 points)
2 moles of a gas are held in a 10 L container at a temperature of 200 °C.

A. Based on the ideal gas equation what is the pressure

$$P = \frac{(2)(473.15)(.08314)}{10} = 7.88 \text{ bar} \quad (7.76 \text{ atm})$$

B. If the actual pressure is found to be 7.89 atm.
Are the intermolecular forces dominated by attractive or repulsive forces? Explain

$$Z = \frac{PV}{nRT} = \frac{(7.89)(10)}{(2)(.08206)(473.15)} = 1.01 \quad \text{repulsions}$$

or $P_{RG} > P_{IG}$

C. If the van der Waals (VDW) constants for this gas are a = 10 L^2 atm mol^{-2} b = 0.14 L mol^{-1}.
What pressure does the VDW equation predict?

$$P = \frac{nRT}{V-nb} - \frac{an^2}{V^2} = \frac{(2)(.08206)(473.15)}{10-(2)(.14)} - \frac{10(2)^2}{10^2}$$

$$= 7.59 \text{ atm}.$$

D. Does the VDW emphasize the correct intermolecular force?

NO predicts that attractions dominate.

10. (15 points)
Given the fact that CCl_4 has a higher boiling point of $CHCl_3$, which would you predict would have a higher boiling point CBr_4 or $CHBr_3$? In your answer discuss both dipole-dipole and dispersion forces.

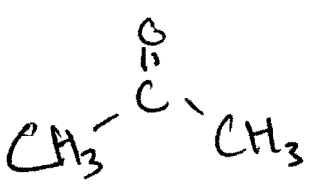
CCl_4 has stronger attractions than $CHCl_3$ despite the fact that $CHCl_3$ has a dipole.

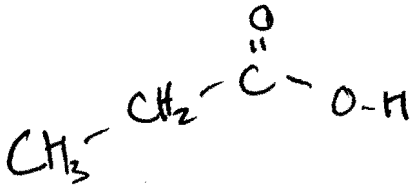
The dispersion forces for CBr_4 will be even larger as Br is more polarizable than Cl

The dipole for $CHBr_3$ will be smaller than $CHCl_3$

∴ CBr_4 higher BP than $CHBr_3$

11. (10 points)
Which would you expect to have a higher surface tension, acetone $(CH_3)_2CO$ or propanoic acid (C_2H_5COOH)? Explain your answer given specifics regarding the intermolecular forces.





H-bonding

similar MW ∴ similar dispersion.

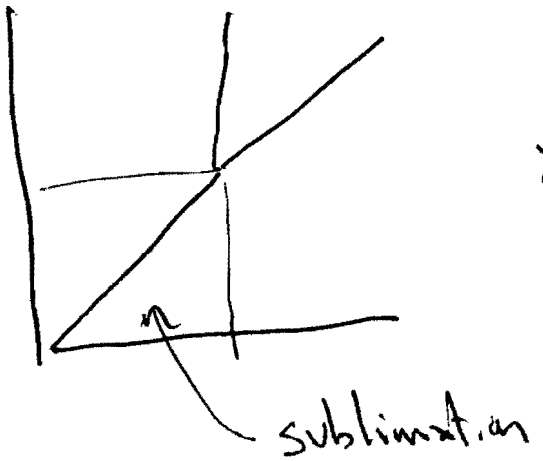
similar dipole if any the acid has more polar

B.I.G. Acid has H-bonding.

∴ propanoic acid stronger IMF

higher surface tension.

12. (10 points)
Iodine sublimes at 298 K. Based on this do you expect the triple point to be at a higher or lower temperature? Or does it depend on the pressure?



sublimation only at T & P below the triple point.

∴ triple point at higher T than 298

13. (20 points)
The vapor pressure of ethanol at 35°C is 0.132 atm.

If 10 g of ethanol (C_2H_5OH) is placed into an evacuated 10 L container at a constant temperature of 35°C what is the final pressure in the container? (give your answer in atm)

0.132

Is there any liquid ethanol remaining? If so, how much? (give your answer in grams)

assuming it is ideal $n = \frac{PV}{RT} = \frac{(.132)(10)}{(.08206)(308.15)} = .052$ moles → 2.3 g

∴ 7.6 g of liquid

If the container was 1000 L what is the pressure?

Is there any ethanol remaining? If so how much?

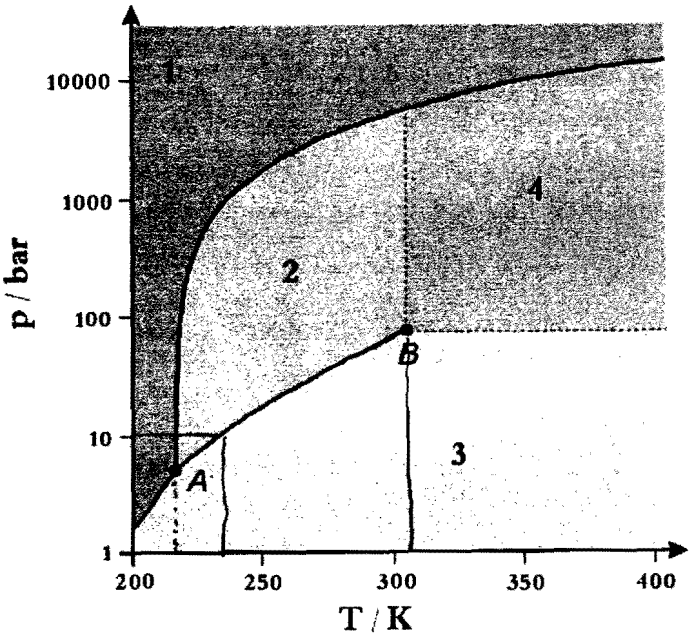
what is n for 1000 L? → 5.2 moles. more than all the liquid.

∴ all evaporates is no liquid left. 10 g → .217 mol

together.

$P = \frac{nRT}{V} = \frac{(.217\ mol)(.08206)(308.15)}{1000} = 5.49 \cdot 10^{-3}$ atm

14. (15 points) Below is a phase diagram of a CO_2 (note the logarithmic scale for the pressure).



Estimate the temperature of the triple point?

~~305 K~~ 215 K

At what temperature is the vapor pressure = 10 bar?

240K

Is this the vapor pressure of the solid or the liquid (or both)?

Liquid

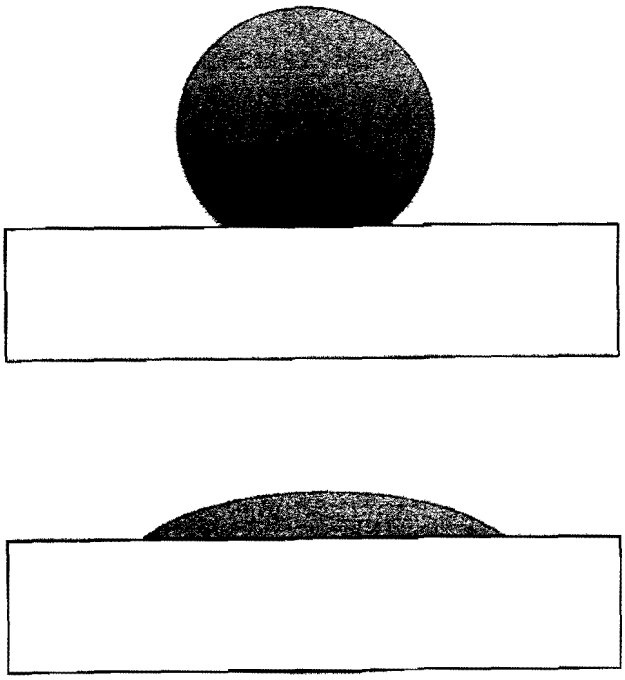
15. (10 points)
You have a 275 cm^3 block of a particular metal at 298K. When you raise the temperature to 500K you find the volume is now 276 cm^3. Estimate the thermal expansion coefficient for this substance.

$$\alpha \approx \left(\frac{1}{V}\right)\left(\frac{\Delta V}{\Delta T}\right) = \frac{1}{275}\left(\frac{1}{\cancel{302}\ 202}\right)$$

$$\alpha = \cancel{1.8 \cdot 10^{-5}\ K^{-1}}$$

$$1.8 \cdot 10^{-5}\ K^{-1}$$

Extra Credit (3 points each)



1. Above is a picture of a liquid drop on two surfaces. Discuss the difference in intermolecular forces for the two pictures specifically dealing with the forces between the liquid molecules and themselves and the liquid molecules and the surface.

Potentially Useful Information

$R = 8.314\ J\ K^{-1}\ mol^{-1}$

$R = 8.206 \times 10^{-2}\ L\text{-}atm\ K^{-1}\ mol^{-1}$

$R = 8.314 \times 10^{-2}\ L\text{-}bar\ K^{-1}\ mol^{-1}$

$PV = nRT$

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

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

$$\alpha = \left(\frac{1}{V}\right)\left(\frac{\partial V}{\partial T}\right)_p \approx \left(\frac{1}{V}\right)\left(\frac{\Delta V}{\Delta T}\right)_p$$

$$\kappa = \left(\frac{-1}{V}\right)\left(\frac{\partial V}{\partial P}\right)_T \approx \left(\frac{-1}{V}\right)\left(\frac{\Delta V}{\Delta P}\right)_T$$

Periodic Table of the Elements

1A												3A	4A	5A	6A	7A	8A
1												13	14	15	16	17	18
1 H 1.008	2A 2																2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.41	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (281)	111 Rg (272)							

58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)