Name: _____

GENERAL CHEMISTRY
CHEM. 111 SEC. 001

EXAM I

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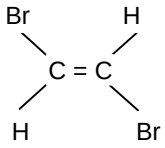
Spring, 2006

Answer all the questions. Answers written on the examination paper will not be graded. Use the blank sheets at the back of the exam for your answers. Credit will not be given for numerical questions unless all relevant calculations are shown. Please give answers to numerical calculations to 3 significant figures.

1. For the following compounds:

   i) N_2

   ii)



   iii) $CH_3CH_2CH_3$
   iv) CH_3CH_2OH

   a) Do they have non-polar bonds, polar bonds or a mixture of both?

   6 points

   b) Are the compounds polar or non polar? Explain why. (Credit will not be given without a correct explanation)

   20 points

   c) Give one example of a polar and one example of a non-polar bond taken from the above compounds.

   2 points

   d) List all the forces of interaction present in each of the compounds above.

   6 points

2. a) Explain the source of the force of interaction in the following types of forces.

      i) London dispersion forces
      ii) Dipole – Dipole forces

   10 points

   b) For the following two compounds:

      i) $CH_3CH_2CH_3$
      ii) $CH_3CH_2\ CH_2CH_3$

      1) If the two compounds are at the same temperature, what can we say about their average kinetic energies?

      2 points

2) What can we say about the average velocities of the molecules?

2 points

3) Which compound will have the higher boiling point temperature, explain the reasons for your choice. (Credit will not be given without a correct explanation.)

5 points

c) The compound CH_3Cl has a dipole movement. If the dipole movement is 1.68 Debyes, calculate the percent ionic character of the C-Cl bond if it has a bond length of 1.5pm.

5 points

3. a) The following two compounds have about the same molecular weight, but very different boiling points. Explain the difference in boiling point.

Compound	Mol. Wt.	Boiling Point
$CH_3CH_2CH_3$ (propane)	~ 44	$-42^{O}C$
CH_3CN (acetonitrile)	~ 41	$82^{o}C$

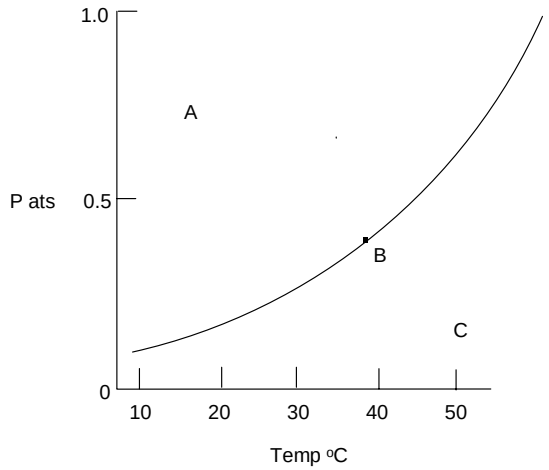
5 points

b) The following two compounds have about the same molecular weight, but very different boiling points. Explain the difference in boiling points.

Compound	Mol. Wt.	Boiling Point
HF	~20	$19.5^{O}C$
H_2O	~18	$100^{O}C$

5 points

4. a)



The above diagram is a vapor pressure diagram for a compound.

i) At point 'A' in the diagram, what phase(s) can the compound exist in at equilibrium?

3 points

ii) At point 'B' in the diagram, what phase(s) can the compound exist in at equilibrium?

3 points

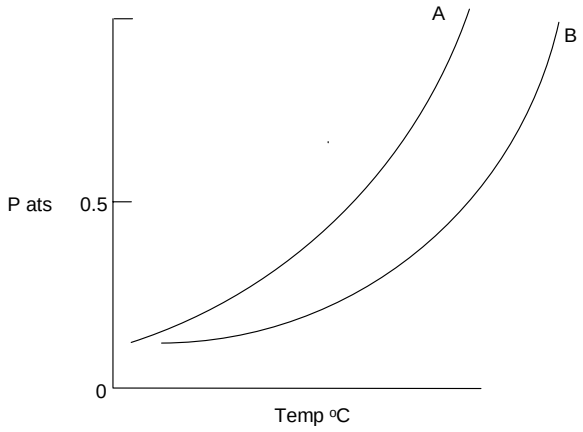
iii) At point 'C' in the diagram, what phase(s) can the compound exist in at equilibrium?

3 points

iv) At a pressure of 0.5 ats at what temperature will the compound boil?

3 points

b)



The above diagram is a vapor phase diagram for two compounds 'A & B':

i) Which compound has the higher boiling point at a given pressure?

3 points

ii) Which compound has the largest force of interaction?

3 points

c) Explain why a liquid cools as it evaporates.

5 points

d) Explain why the temperature of a boiling liquid remains constant.

5 points

e) Fore the following equilibrium:

$$A_{gas} \leftrightarrow A_{liquid}$$

i) If I increase the temperature, which way will the equilibrium shift? Explain your answer. (Credit will not be given without a correct explanation)

4 points

USEFUL INFORMATION

1 Debye (D) = 3.336×10^{-30} coulomb meters

Charge on an electron = 1.6×10^{-19} coulombs

$\mu = Qr$

ANSWERS

1. a)
   i) Non polar bonds
   ii) Non polar and polar bonds
   iii) Non Polar bonds
   iv) Non polar and polar bonds

   b) i) Non polar. N_2 is a diatomic symmetrical molecule with non polar bonds and is therefore non polar.

   ii) This compound has polar and non polar bonds. However, the compound is symmetrical and the effect of the two C-Br polar bonds cancel each other out and therefore the compound is non polar.

   iii) Non polar. Like N_2 this compound has only non polar bonds and is therefore non polar.

   iv) Polar. This compound has polar and non polar bonds. The polar C-O-H bonds are asymmetrical which makes the compound polar.

   c) Non polar C-H
   Polar C-Br

   d) i) London dispersion
   ii) London dispersion
   iii) London dispersion
   iv) London dispersion, dipole-dipole, hydrogen bonding

2. a)
   i) London dispersion or induced dipole-dipole interaction occur because when two atoms or molecules approach each other, their electron clouds become slightly distorted making the molecule slightly polar. The slightly positive end of one molecule now attracts the slightly negative end of another molecule giving rise to a slight attraction between the molecules.

   ii) Dipole-Dipole forces occur in polar molecules. The negative end of one molecule attracts the positive end of another molecule giving rise to an attraction between the molecules.

   b) 1) Their average kinetic energy is the same

   2) Propane – the lighter molecule has the higher average velocity

   3) Butane has the higher boiling point. It has the larger mass and therefore at any given temperature the lower average velocity. The lover average velocity allows the forces of interaction, which are the same in both molecules (London Dispersion) to be more effective on the slower moving molecules hence giving a higher boiling point. The inter-molecule forces, London Dispersion, are also a little stronger on balance in the larger molecule as the electron cloud is less tightly held.

   c) 23.4%

3. a) As both compounds have approximately the same molecular weight it must the intermolecular forces that are effecting the boiling point. Acetonitrile has dipole-dipole interactions while propane has only London dispersion forces. As dipole-dipole interactions are stronger than London dispersion acetonitrile has the higher boiling point.

   b) Both compounds have approximately the same molecular weight and the same forces of interaction (hydrogen bonding). Therefore, they would be expected to have the same boiling point. Another factor must be at work here and that is that water can form more than one hydrogen bond and therefore has the higher boiling point.

4. a)
   i) Liquid
   ii) Gas
   iii) Liquid and Gas
   iv) ~ 45° C

   b)
   i) B
   ii) B

   c) In a liquid it is only the molecules with the largest Kinetic Energy that can escape from the liquid. This reduces the average kinetic energy of the molecules in a liquid so it cools.

   d) In a boiling liquid, the heat energy being put into the system is used to move the atoms or molecules apart to form a gas. This just increases the potential energy of the system not the kinetic energy. Therefore the temperature does not change as it depends on the average kinetic energy of the system.

   e) The equilibrium shifts to the left. When I raise the temperature, I add heat energy to the system. The constraint I am putting on the system is to heat it. The equilibrium will move in a direction to oppose the constraint. i.e. it will try to cool down. It can do this by creating more gas. i.e. evaporation which tries to cool the system.