



Escuela Politécnica Superior
Universidad Carlos III de Madrid

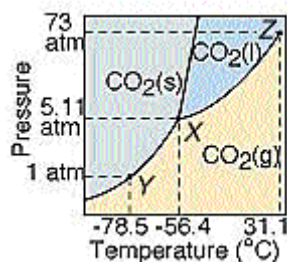
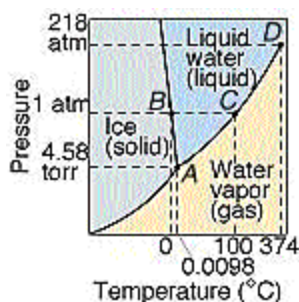
Chemistry
Mid Term Exam. Topics 1-5

1.- (1.5 p) (a) (0.8 p) Determine de Lewis structure, lone pairs, molecular geometry and hybridization of the central atom in the following two molecules: BH_3 and NH_3 . (b) (0.7 p) Discuss the polarity of both molecules and their acid-base properties.

2.- (1.5 p) Consider the following statements about electromagnetic radiation and decide whether they are true or false. If they are false correct them. (a) (0.3 p) Photons of ultraviolet radiation have less energy than photons of infrared radiation. (b) (0.3 p) The kinetic energy of an electron ejected from a metal surface when the metal is irradiated with ultraviolet radiation is independent of the frequency of the radiation. (c) (0.3 p) The energy of a photon is inversely proportional to the wavelength of the radiation. (d) (0.6 p) A lamp rated at 40 W ($1\text{W} = 1\text{J}\cdot\text{s}^{-1}$) emits blue light of wavelength 470 nm. How many moles of photons of blue light can the lamp generate in 2 seconds?

DATA: $h = 6.626 \cdot 10^{-34} \text{ J}\cdot\text{s}$; $c = 2.997 \cdot 10^8 \text{ m}\cdot\text{s}^{-1}$; $N_A = 6.022 \cdot 10^{23}$.

3.- (1.5 p) Consider the equilibrium phase diagrams of water and carbon dioxide and answer the following questions:



(a) (0.3 p) Which are the coordinates of critical points, triple points and normal boiling points?

(b) (0.9 p) The slopes for the solid-liquid equilibrium curves have different sign for both substances. Explain why.

(c) (0.3 p) Describe all the changes that will take place if the pressure of a sample of water at 0°C is decreased from 218 atm to 0.1 torr.

4.- (1.5 p) Vapor pressure of benzene and ethanol at 50°C are: 271 and 220 Torr respectively.

(a) (0.5 p) Calculate the vapor pressure of a mixture containing the same weights of both substances at 50°C as well as, (b) (0.5 p) the molar fraction of ethanol in the vapor phase assuming ideal behavior. (c) (0.5 p) Vapor pressure of the mixture at 50°C was measured in an experiment and it was obtained a value of 300 torr. Compare with your result and extract the sign of the enthalpy of mixing both substances. Will the mixture present an azeotropic composition?

DATA: $M(\text{ethanol})=46 \text{ g/mol}$, $M(\text{benzene})=78\text{g/mol}$.

5.- (2 p) Citric acid (AH_3) is an organic triprotic acid. The pair $[\text{AH}^{2-}]/[\text{A}^{3-}]$ is commonly used as a buffer in biochemistry. An enzymatic reaction takes place in 10 mL of a buffered solution with total buffer concentration of 0.12 M and initial pH of 7; during the reaction $2 \cdot 10^{-4} \text{ mol}$ of an acid are generated. Determine: (a) (0.8 p) the initial concentration of the two citrate species forming the buffer, (b) (0.8 p) the pH at the end of the enzymatic reaction, and (c) (0.4 p) the pH at the end of the enzymatic reaction without using a buffer solution.

DATA: $\text{pK}(\text{AH}^{2-}) = 6.4$

6.- (2 p) The molar enthalpy of fusion of benzene is 0.9 kJ/mol . Benzene normal melting point is 5.5°C . C_p (in $\text{J/mol}\cdot\text{K}$) values of benzene in the solid and liquid states are 118.4 and 134.8 respectively. Calculate: (a) (1.5 p) the entropy and enthalpy changes when 1 mol of benzene is heated from -20°C to 50°C ; (b) (0.5 p) the free energy change for the solid \rightarrow liquid process at -20°C , 5.5°C and 50°C and discuss the physical meaning of the obtained values.