PRACTICE EXAM #4

Chem1A, General Chemistry I

1.) Use the following data to calculate the total heat absorbed, in kJ, by 238.5 mL of acetone (C_3H_6O) originally at 24.3°C and heated to 78.6°C.

Density (g/mL)	Specific heat capacity for liquid (J/g °C)	Specific heat capacity for vapor (J/g °C)	Heat of vaporization (kJ/mol)	Boiling Point (°C)
0.793	2.16	1.29	31.0	56.5

Use the volume and density to calculate the grams and mols of C_3H_6O present.

$$238.5 \text{ mL } C_3H_6O \times \frac{0.793 \text{ g acetone}}{1 \text{ mL acetone}} = 18\underline{9}.1 \text{ g } C_3H_6O \times \frac{1 \text{ mol acetone}}{58.078 \text{ g acetone}} = 3.2\underline{5}6 \text{ mols } C_3H_6O$$

From 24.3°C → 56.5°C (b.p.): changing temperature, use $q = m\ C_s\ \Delta T$ (for liquid)

$q = ?$; $m = 18\underline{9}.1$ g ; $C_s = 2.16$ J/g °C ; $\Delta T = 56.5°C - 24.3°C = 32.\underline{2}$ °C

$$q = (18\underline{9}.1 \text{ g})(2.16 \text{ J/g °C})(32.\underline{2} \text{ °C}) = 13\underline{1}52 \text{ J} \times \frac{1 \text{ kJ}}{1000 \text{ J}} = 13.\underline{1}5 \text{ kJ}$$

From (l) → (g) at 56.5 °C: changing phase, use ΔH vaporization

ΔH vap = 31.0 kJ/mol ; mols = $3.2\underline{5}6$ mols C_3H_6O

$$3.2\underline{5}6 \text{ mols } C_3H_6O \times \frac{31.0 \text{ kJ}}{1 \text{ mol acetone}} = 10\underline{0}.9 \text{ kJ}$$

From 56.5°C → 78.6°C: changing temperature, use $q = m\ C_s\ \Delta T$ (for vapor)

$q = ?$; $m = 18\underline{9}.1$ g ; $C_s = 1.29$ J/g °C ; $\Delta T = 78.6 °C - 56.5°C = 22.\underline{1}$ °C

$$q = (18\underline{9}.1 \text{ g})(1.29 \text{ J/g °C})(22.\underline{1} \text{ °C}) = 53\underline{9}1 \text{ J} \times \frac{1 \text{ kJ}}{1000 \text{ J}} = 5.3\underline{9}1 \text{ kJ}$$

q total = $13.\underline{1}5$ kJ + $10\underline{0}.9$ kJ + $5.3\underline{9}1$ kJ = $11\underline{9}.4$ → **119 kJ**

2.) A typical brand of root beer contains 0.13% H_3PO_4 by mass. Assume the density of the soda is 1.11 g/mL and that 1 oz. = 29.6 mL.

(A) How many mg of H_3PO_4 are present in one 12 oz. can?

Use 0.13% H_3PO_4 by mass as a conversion factor: 0.13 g H_3PO_4/100 g solution

$$12 \text{ oz. solution} \times \frac{29.6 \text{ mL}}{1 \text{ oz.}} \times \frac{1.11 \text{ g solution}}{1 \text{ mL}} \times \frac{0.13 \text{ g } H_3PO_4}{100 \text{ g solution}} \times \frac{1000 \text{ mg}}{1 \text{ g}} = 5\underline{1}2 \text{ mg} \rightarrow$$

510 mg H_3PO_4

(B) Calculate the solution's concentration of H_3PO_4 in molarity (M).

Assume 100 g of solution. Convert 0.13 g H_3PO_4 to mols H_3PO_4 and 100 g solution to L.

$$0.13 \text{ g } H_3PO_4 \times \frac{1 \text{ mol } H_3PO_4}{97.994 \text{ g } H_3PO_4} = 0.001\underline{3}2 \text{ mols } H_3PO_4$$

$$100 \text{ g solution} \times \frac{1 \text{ mL soln}}{1.11 \text{ g soln}} \times \frac{1 \text{ L}}{1000 \text{ mL}} = 0.090\underline{0} \text{ L solution}$$

$$\frac{0.00132 \text{ mols}}{0.0900 \text{ L}} = 0.01\underline{4}7 \rightarrow \mathbf{0.015\ M\ H_3PO_4}$$

(C) Calculate the solution's concentration of H_3PO_4 in molality (m), assuming all the other components in the soda to be the solvent.

Assume 100 g of solution. 100 g solution – 0.13 g H_3PO_4 = $99.8\underline{7}$ g solvent

$$99.8\underline{7} \text{ g solvent} \times \frac{1 \text{ kg}}{1000 \text{ g}} = 0.0998\underline{7} \text{ kg solvent}$$

$$\frac{0.00132 \text{ mols}}{0.09987 \text{ kg}} = 0.01\underline{3}2 \rightarrow \mathbf{1.3 \times 10^{-2}\ m}$$

3.) A 113 mL sample of 5.2 M hexane (C_6H_{14}) is mixed with 125 mL of 4.8 M ethanol (C_2H_5OH) at 25°C. The vapor pressures of pure hexane and pure ethanol are 151 torr and 55.1 torr, respectively.

(A) Calculate the partial pressure of hexane over the solution, in torr.

Calculate the mole fraction of hexane.

$113 \text{ mL hexane} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{5.2 \text{ mols hexane}}{1 \text{ L}} = 0.5\underline{8}7 \text{ mols hexane}$

$125 \text{ mL ethanol} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{4.8 \text{ mols ethanol}}{1 \text{ L}} = 0.6\underline{0} \text{ mols ethanol}$

$X(\text{hexane}) = \frac{0.587 \text{ mols}}{0.60 \text{ mols} + 0.587 \text{ mols}} = 0.4\underline{9}4$

Use $P = X P°$

P (hexane) = (0.4$\underline{9}$4)(151 torr) = 7$\underline{4}$.5 → **75 torr**

(B) Calculate the partial pressure of the ethanol over the solution, in torr.

Calculate the mole fraction of ethanol.

X (ethanol) = 1 – 0.4$\underline{9}$4 = 0.5$\underline{0}$6

Use $P = X P°$

P (ethanol) = (0.5$\underline{0}$6)(55.1 torr) = 2$\underline{7}$.8 → **28 torr**

(C) Calculate the total pressure above the solution, in torr.

Use Dalton's Law: P_T = P(hexane) + P(ethanol)

P_T = 75 torr + 28 torr = 10$\underline{3}$ → **103 torr**

(D) Calculate the mole fraction of hexane in the **vapor** above the solution.

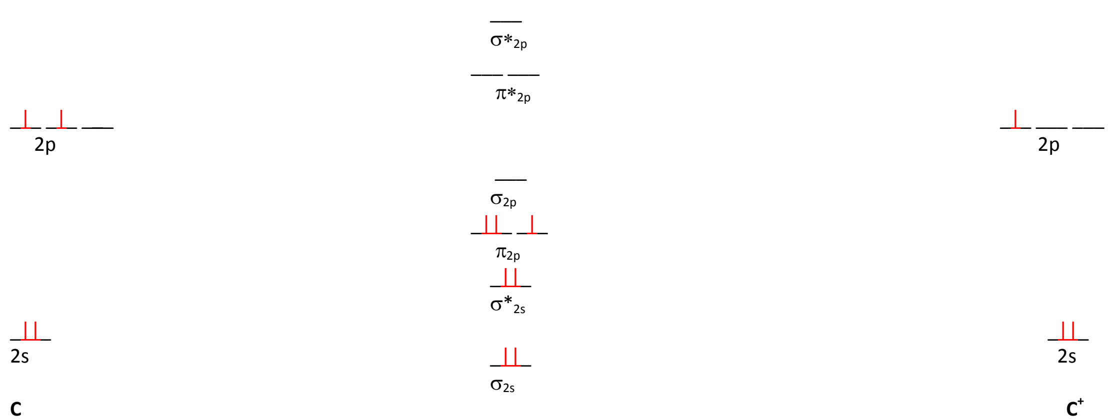
Use Dalton's Law: $P = X P_T$ so $X(\text{vapor}) = P/P_T$

$X(\text{hexane}) = \frac{75 \text{ torr}}{103 \text{ torr}} = 0.7\underline{2}8$ → **0.73**

(E) Calculate the mole fraction of ethanol in the **vapor** above the solution.

1 – 0.7$\underline{3}$ = 0.2$\underline{7}$ → **0.27**

4.) Draw the molecular orbital diagram for C_2^+. What is the expected bond order? Is it stable? Is it paramagnetic or diamagnetic?

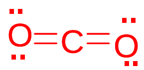


Bond Order: ½(5 – 2) = **3/2**, **stable** (bond order > 0)

Paramagnetic; one unpaired electron

5.) For each of the following molecules, determine the **electronic domain** and the **molecular** geometries around *each* central atom. Also list the **hybridization** expected around *each* central atom and give the total number of σ or π bonds present in the structure.

a.) CO_2

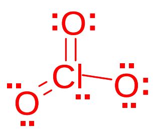


C is central, 2 bonding groups, 0 nonbonding groups

Electronic: **Linear** ; Molecular: **Linear**

sp hybridized, 2 σ + 2 π bonds

b.) ClO_3^-

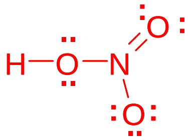


Cl is central, 3 bonding groups, 1 nonbonding group

Electronic: **Tetrahedral** ; Molecular: **Trigonal Pyramidal**

sp^3 hybridized, 3 σ + 2 π bonds

c.) $HONO_2$



O is central: 2 bonding groups, 2 nonbonding groups

Electronic: **Tetrahedral** ; Molecular: **Bent**

sp^3 hybridized

N is central: 3 bonding groups, 0 nonbonding groups.

Electronic: **Trigonal Planar** ; Molecular: **Trigonal Planar**

sp^2 hybridized

4 σ + 1 π bonds