Chemistry
Aerospace Engineering
Regular Exam, May 29th, 2012

Universidad Carlos III de Madrid

SURNAME .... **NAME** .... **GROUPS 45, 46**

EXAM (60%)

1. **(1 marks, 10 mins)** Consider the data provided in the table below and explain: i) the variation observed in the melting points of these compounds and ii) whether they are expected to be soluble in water.

	Potassium chloride	**Nitrogen**	**Ethane**	**Propane**	**Ethanol**	**Acetic acid**	**C (diamond)**
Melting point (ºC)	776	-210	-183	-138	-114	17	3550
Soluble in water (Y/N)							

2. **(1.0 marks, 15 mins)** The heat of combustion of **ethane gas** is **1561 kJ/mol**. Assuming that 60 % of the heat is useful, how many liters of ethane (S.T.P.) must be burned to supply enough heat to convert 50 kg of water at 10ºC to steam at 100 ºC?

Data: $R = 0.082$ atm·l·mol^{-1}·K^{-1}; M (H_2O) = 18 g/mol; M (ethane) = 30.07 g/mol;
ΔH_{vap} (H_2O, 100ºC) = 2257 kJ/kg; c_p (H_2O,25ºC) = 4.177 kJ/kg ºC (Assume c_p to be constant in that temperature range);

3. **(2.0 marks, 20 mins)** A solution made by adding solid **sodium hypochlorite (NaClO)** to enough water to make 2.00 L of solution has a pH of 10.50. Using the information given below:
   a) (0.25 m) Write down the ionization equilibrium of the salt. Will any of the ions react with water? Why?
   b) (1.0 m) Calculate the initial concentration of the NaClO solution in moles per liter of solution.
   c) (0.25 m) Calculate the grams of NaClO that were added to the initial solution.
   d) (0.5 m) How will the solubility of this salt in water be affected by the addition of HCl (aq)?

   Data: $K_a(HClO) = 2.9 \cdot 10^{-8}$, K_w (H_2O, 25 ºC) = 10^{-14}; M(NaClO) = 74.44 g mol^{-1}

4. (3 marks, 30 mins) Given the following reaction: $A + B \rightarrow C$ and taking into account the results obtained in the following experiments,

$[A]_0$ (mol l^{-1})	$[B]_0$ (mol l^{-1})	$R_{25°C}$ (*10^7) (mol l^{-1} min^{-1})	$R_{40\ °C}$ (*10^7) (mol l^{-1} min^{-1})
0.01	0.01	3.78	4.82
0.01	0.02	5.35	6.82
0.02	0.01	7.56	9.64

Answer the following questions:

a) Calculate the **partial orders** of the reaction for A and B. (Assume the partial orders remain constant within that temperature range).
b) Is the chemical reaction an elemental process? Why?
c) Determine the values of the **kinetic constant** at the two temperatures 25 ºC and 40 ºC.
d) Determine the **activation energy** of the reaction.
e) The **rate equations** at the two temperatures (25 ºC and 40 ºC) assuming that the mechanism of the reaction remains the same within this temperature range;
f) If the enthalpy for the reaction at 40 ºC is ΔH = -2 kcal·mol^{-1} and the entropy change is ΔS = 2 cal·mol^{-1} K^{-1}, calculate **Gibbs free energy** and the value of the **equilibrium constant** at that temperature.

Data: R = 8.314 J·mol^{-1}·K^{-1} = 1.987 cal·mol^{-1}·K^{-1}

5. **(1.25 marks, 20 mins)** An experiment requires an environment of humid air enriched in oxygen. Three input streams are fed into an evaporation chamber to produce an output stream with the desired composition:

   Stream A: liquid water fed at a rate of 20.0 cm^3/min.

   Stream B: Air (21% O_2; 79% N_2, mole fraction).

   Stream C: Pure oxygen, with a molar flow rate **one – fifth** of the molar flow rate of **stream B**.

The **output gas** is analyzed and is found to contain 1.5 % moles of water.

a) (*0.5 m*) Draw and label a flowchart of the process
b) (*0.25 m*) Calculate the flow rate of the output gas in mol/min.
c) (*0.25 m*) Calculate the flow rate of B and C streams in mol/min.
d) (*0.25 m*) Determine the composition of the output stream (mole fraction, %).

Data: $\rho(H_2O)$ = 1g/cm3; $M(H_2O)$ = 18 g/mol

6. **(0.75 mark, 10 mins)** How many hours are required to plate 25.00 g of copper metal from a 1.00 M $CuSO_4$ (aq) solution, by using a current of 3.00 A.

Data: F = 96500 C/mol; M(Cu) = 63.5 g/mol

7. **(1.0 marks, 15 mins)** Indicate whether the following statements are **true (T)** or **false (F)**.

Correct answers +0.1p; Incorrect answers -0.05p.

	1	The dehydrogenation reaction is an elimination reaction that usually yields as a product an organic derivative with a double or a triple bond.
	2	The solubility in water of carboxylic acids of the same homologous series increases with the number of carbon atoms of the chain.
	3	The reaction of a CARBOXYLIC ACID with an ALCOHOL usually yields an ester as a result of a condensation reaction.
	4	Pyrogenation of coal is based on a thermal treatment with oxygen at high temperature to obtain liquid hydrocarbons.
	5	From methane it is possible to obtain syngas ($CO + H_2$) which is used as raw material for many industrial processes.
	6	In the combustion of a fuel, a lean mixture is a mixture with an excess of air.
	7	Linear alkenes usually have higher boiling points than linear alcohols of the same number of carbon atoms.
	8	Given a binary mixture of two volatile substances (A & B), in a rectifying column, the compound with the higher boiling temperature will be obtained at the head of the column.
	9	Steam distillation is used mainly to obtain substances that are highly soluble in water vapour and temperature sensitive materials
	10	In organic reactions, a homolytic bond cleavage yields as a result two ionic compounds, the carbocation and a carbanion.