Escuela Politecnica Superior
Universidad Carlos III de Madrid

FINAL EXAM

EXAM (60%)

SURNAME.....NAME.....

1.- (1.2 points) Human body approximately contains 250 g of potassium from which 0.012 % is ^{40}K, a beta emitter with $t_{1/2}$ = $1.25 \cdot 10^9$ y (1.311 MeV). Answer succinctly the following questions:

a) *(0.2 points)* How changes Z and N in a beta emission process?
b) *(0.2 points)* Is it typical for nuclides with N/Z >>1 or N/Z <<1?
c) *(0.2 points)* What is activity? How is it related with the mean lifetime?
d) *(0.6 points)* Calculate the activity of ^{40}K and the absorbed dose (in Gy) for a human (80 kg) along all his life (80 y).

Data: 1MeV = 10^6 eV; 1 eV = $1.6 \cdot 10^{-19}$ J; 1 y = 365.25 d; $N_A = 6.022 \cdot 10^{23}$; M_K = 39.1 g·mol^{-1}

2.- *(1 point)* Consider the following molecules HBr, CO_2, SO_2, XeF_4:

a) *(0.2 point)* Write their Lewis structures.
b) *(0.2 point)* Indicate how many lone pairs has the central atom and describe the molecular geometry.
c) *(0.2 point)* Justify which of them have non zero dipolar moment.
d) *(0.2 point)* Justify which of them are water soluble.
e) *(0.2 point)* Which is the bond order for HBr? Justify the answer.

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3.- *(1 point)* Concerning thermochemistry answer the following questions:

a) *(0.25 point)* What is internal energy?
b) *(0.25 point)* What is enthalpy?
c) *(0.25 point)* What are reversible and irreversible processes? Explain using a gas expansion process.
d) *(0.25 point)* We need to compress a gas inside a piston. How we do it with as little work as possible?

4.- *(1.4 points)* A 258.3 cm^3 chamber equipped with a piston contains CH_4 at 10 atm. and 77ºC. 6.4 g of O_2 are injected in the chamber, being this amount more than needed for a complete combustion of methane. After combustion the system returns to the initial temperature and it is found 5 L of a gas mixture at an unknown pressure over a certain amount of liquid water.

a) *(0.2 points)* Balance the combustion equation.
b) *(0.8 point)* Find the amount of water in the gas mixture and the volume of liquid water.
c) *(0.4 points)*Calculate the volume percentage composition of the gas mixture after combustion.

Data: $\rho(H_2O_L, 77ºC)$= 0.978 g·cm^{-3}; $P(H_2O_g, 77ºC)$= 314.1 mmHg;R = 0.082 atm·L·mol^{-1}·K^{-1}; $M(O_2)$= 32 g·mol^{-1}; $M(H_2O)$= 18 g·mol^{-1}.

5.- *(1.4 points)* Water is added to 16.4 g of sodium acetate to prepare 500 mL of solution. Calculate:

a) *(0.4 points)* pH of the solution.
b) *(0.6 points)* The weight of acetic acid that must be added to obtain a pH of 5?
c) *(0.4 point)* The weight of solid silver nitrate ($AgNO_3$) we must add to the initial sodium acetate solution to begin precipitation of silver acetate ($AgCH_3COO$).

Data: M(acetic acid)=60 $g \cdot mol^{-1}$; M(sodium acetate)=82 $g \cdot mol^{-1}$; K_a(acetic acid)=$1.8 \cdot 10^{-5}$; M($AgNO_3$) =170 $g \cdot mol^{-1}$; $K_s(AgCH_3COO) = 1.94 \times 10^{-3}$.

6.- *(1.4 points)* Consider a cell in which the following reaction takes place:

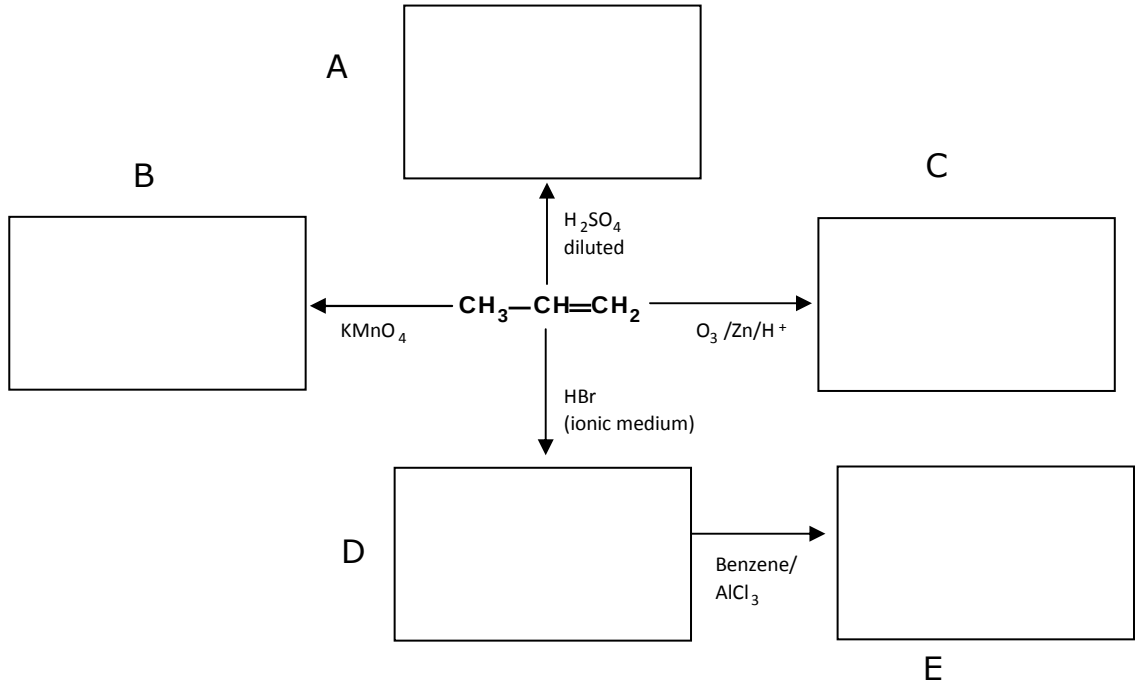
$$5Fe^{2+}(ac) + MnO_4^-(ac) + 8H^+(ac) \leftrightarrow 5Fe^{3+}(ac) + Mn^{2+}(ac) + 4H_2O(l)$$

Platinum electrodes are introduced in both anode and cathode, a saline bridge connects the two electrodes and the electrodes are connected to a voltmeter.

a) *(0.2 points)* What is the standard potential of the cell?
b) *(0.2 points)* What reaction takes place in the anode and the cathode? What is the direction of electron movement through the external circuit? Draw a scheme of the cell.
c) *(0.4 points)* What is the equilibrium constant of the reaction at 25 ºC?
d) *(0.6 points)* What is the cell potential if $[H^+]$ is decreased from its standard value to 10^{-4}M keeping constant the concentration of all other species?

Data: $E^0(MnO_4^-/Mn^{2+})$ = 1.512 V; $E^0(Fe^{3+}/Fe^{2+})$ = 0.771 V

7.- (*1,2 point*) Complete the following set of reactions and draw the stereoisomers of product B.



8. (*1,4 point*) Product **A** is obtained reacting benzene with one mol of CH_3Cl using $AlCl_3$ as catalyst. **A** is subjected to the following set of reactions: a) Br_2 in the presence of iron as catalyst giving a single product **B** because of steric hindrance, b) magnesium under anhydrous conditions (ether) giving product **C**, c) carbon dioxide and subsequently water, giving the product **D**, d) thionyl chloride giving **E** which reacts with methylamine giving **F**. Deduce the structural formulas of compounds **A** to **F**.