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EDUCATIONAL DATA

HONDURAN SELECTION TEST FOR THE LAVOISIER INTERNATIONAL CHEMISTRY OLYMPIAD

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HONDURAN SELECTION TEST FOR THE LAVOISIER INTERNATIONAL CHEMISTRY OLYMPIAD

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Abstract

The Lavoisier International Chemistry Olympiad (LIChO) is an emerging international contest for high-school and middle-school students interested in the subject of chemistry. This competition is organized by the Organizing Center for STEM Olympiad (OCSO), a non-profit organization based in Indonesia with the goal of integrating young people from all over the world into the STEM field. In particular, the objective of the LIChO is to promote critical thinking and problem solving through challenges related to chemistry. The recent educational contest boom in Honduras gave birth to many projects, such as the Honduran Physics Olympiad in 2017, the Honduran Astronomy Olympiad in 2022, and of course, the Honduran Chemistry Olympiad in 2021. Honduras, as a beginner country in the international chemistry Olympiad stage has interest in making their students challenge themselves by participating in advanced-level tournaments such as the LIChO. In this article, we share the selection test used to choose the team members that represented Honduras in this competition.

Keywords: *STEM in Honduras, LIChO, chemistry Olympiad, chemistry, selection test.*

Examen Selectivo de Honduras Para la Olimpiada Internacional de Química Lavoisier

Resumen

La Olimpiada Internacional de Química Lavoisier (LIChO) es un concurso internacional para estudiantes de secundaria interesados en la asignatura de química. En concreto, el objetivo de la LIChO es promover el pensamiento crítico y la resolución de problemas a través de retos relacionados con la química. El reciente auge de los concursos educativos en Honduras dio lugar a muchos proyectos, como la Olimpiada Hondureña de Física en 2017, la Olimpiada Hondureña de Astronomía en 2022 y, por supuesto, la Olimpiada Hondureña de Química en 2021. Honduras, como país principiante en la etapa de las olimpiadas internacionales de química tiene interés en que sus estudiantes se desafíen participando en torneos de nivel avanzado como la LIChO. En este artículo, compartimos la prueba de selección utilizada para elegir a los miembros del equipo que representó a Honduras en esta competencia.

Palabras clave: *STEM en Honduras, LIChO, Olimpiada de química, química, prueba de selección.*

Lavoisier International Chemistry Olympiad

Selection Test Honduras

Problem 1. A 200.0 mL sealed ampule has a temperature of 400.0 K and a pressure of 840.0 Torr. The ampule contains 1.2964 g of a mixture of xenon tetroxide and “gas X”, which is a substance composed of xenon and fluorine.

a. Explain why these gases deviate significantly from behaving like an ideal gas.
b. What is the pressure, in atm, of the container if the temperature is raised to 1000 ^{o}C? From now on, assume that the mixture behaves like an ideal gas.
c. If the partial pressure of “gas X” is 0.130 atm at 400.0 K, what is the molar concentration of xenon tetroxide in the container?
d. The molar fraction of xenon tetroxide in the ampule is 0.8923, find the molecular formula of “gas X”.
e. Which gas has a higher average speed at 400K? Provide your reasoning.

Problem 2. Write net ionic equations for the following reactions. You don’t need to balance the reaction equations.

a. Solid calcium carbonate’s reaction with dilute nitric acid.
b. Dilute sodium hydroxide’s reaction with dilute hydrochloric acid.
c. Aqueous carbon dioxide’s reaction with aqueous calcium hydroxide.
d. Solid sodium’s reaction with liquid water.
e. Aqueous silver nitrate’s reaction with aqueous potassium iodide.

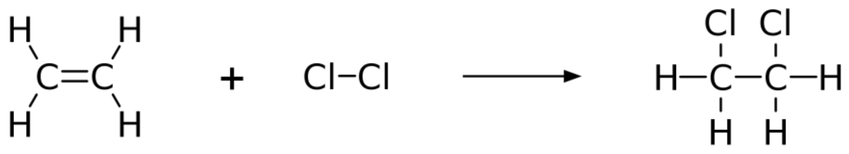
Problem 3. A galvanic cell was constructed using copper, zinc, and their respective sulfates solutions with a 1 M concentration. The reaction is carried out under standard conditions (25 ^{o}C and 1 atm). The half-reactions of the copper ii/copper and zinc ii/zinc pairs are shown below.

$Cu^{2+} + 2e^{-} \rightleftharpoons Cu$ +0.34V

$Zn^{2+} + 2e^{-} \rightleftharpoons Zn$ -0.76V

a. Draw a diagram of the galvanic cell with all necessary components, label each component.
b. Write the equation for the overall reaction and calculate the cell’s potential.
c. When setting up the galvanic cell, a student mistakenly used a 0.1 M solution of $ZnSO_4$ instead of the intended 1 M solution. Calculate the cell potential under this condition.
d. Predict the qualitative effect on the cell potential if some NaOH is added to the cathodic compartment.

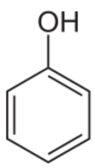
Problem 4. Consider this electrophilic addition reaction:



a. Calculate the theoretical yield, in grams, of $C_2H_4Cl_2$ if the reaction is conducted with 2.50 grams of C_2H_4 and 1.20 grams of chlorine.
b. The final yield of $C_2H_4Cl_2$ was 1.20g. Calculate the percent yield of this reaction.
c. Draw the most stable conformation for the product.
d. Does the product have a dipole moment? Identify the type(s) of intermolecular forces the product molecule exhibits.
e. Are the hydrogen atoms in $C_2H_4Cl_2$ located on the same plane? Draw a diagram explaining your answer.
f. Using the table below, determine the order of the reaction with respect to each reactant.

Partial Pressure of Cl_2 (atm)	Partial Pressure of C_2H_4 (atm)	Rate of Reaction (atm/s)
0.3	0.3	0.0071837
0.3	0.6	0.0071837
0.6	0.3	0.0143674
0.6	0.6	0.0143674

Problem 5. Phenol, pictured on the right, is an organic alcohol with one acidic proton. The pKa of phenol is 10.0. A 50.0 mL solution containing phenol is titrated with a standardized secondary pattern of 0.20 M NaOH. During the titration, 67 mL of the NaOH solution were required to completely neutralize all the phenol.



a. Write the equation for the reaction of phenol with NaOH.
b. Find the original concentration of phenol.
c. What is the pH at the endpoint?

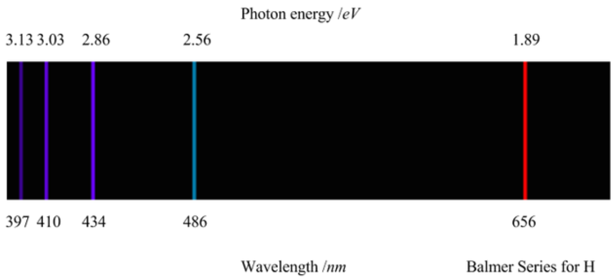
Problem 6. Use the following formulas for the problems.

$$\Delta G = \Delta H - T\Delta S \qquad \Delta G^{o} = -RT \ln K_{eq} \qquad \ln\left(\frac{p_2}{p_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

a. The change in Gibbs free energy for the evaporation of water is 8.43 kJ/mol under standard conditions. What is the vapor pressure of water, in mmHg, at 52.0 degrees Celsius?
b. At the top of Mount Everest, the atmospheric pressure is 0.33 atm. What would the normal boiling point of water be at this point? ΔHvap of water is 40.8 kJ/mol.
c. Find ΔS_{vap} of water at 52 degrees Celsius.

Problem 7. Consider the following reaction scheme. Platinum electrodes are placed in a beaker containing only compound **A** mixed with compound **D**, a strong current is passed through them. At one electrode, a gas **B** is evolved, and at the other electrode, a gas **C** is evolved. Twice as much **B** is formed compared to **C**. Gas **B** is commonly used in the reduction of unsaturated organic compounds. Compound **D** is 22.57% sulfur by mass and 32.37% sodium by mass. Identify compounds **A** through **D**.

Problem 8. During the beginning of the twentieth century, scientists worked on figuring out the nature of the atom using experimental data such as emission spectra. The studies made on the spectra produced by hydrogen derived an equation which you can see below.



$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_f^{\,2}} - \frac{1}{n_i^{\,2}}\right)$$

a. Explain why the hydrogen emission spectra consists of discrete lines instead of a continuous spectrum of light.
b. Explain, using the equation given above, why the hydrogen emission spectra lines become closer together at shorter wavelengths.

In 1922, Albert Einstein won the Nobel Prize for his discovery of the photoelectric effect. The photoelectric effect is the emission of electrons when electromagnetic radiation, such as light, hits a metal, however, only electromagnetic radiation of a above a certain frequency can generate this phenomenon on a certain material.

c. Explain what would happen to the electrons begin ejected if the intensity of the light being projected onto the metal was increased.
d. Explain why electrons need a certain frequency of light to start producing the effect.

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