



The 28th International Science Olympiad for Young
Mathematicians, Physicists and Chemists
November 3, 2015
Chemistry - Form 10



1. OXIDATION REACTIONS – BURNING MATERIALS (7 points)

When metal **X** is burned in air it forms two main products – **A** ($\omega_X = 46.7\%$) and **B** ($\omega_X = 60.0\%$). When non-metal **Y** is burned in air, it forms solid **C** ($\omega_Y = 46.7\%$). Under specific chemical conditions and at temperatures above 1000°C , **Y** forms solid **D** ($\omega_Y = 60.0\%$) which belongs to the same class as **B**. Between themselves **X** and **Y** form solid **E** ($\omega_X = 50.0\%$) which might find its application in so-called **X-Y** batteries that possess much higher specific capacities than currently commercially available **X-ion** batteries.

a) Write the equations for the described reactions using common chemical symbols. **(5 points)**

b) “**X**-burning” and “**Y**-burning” processes have a different meaning in astrophysics than in chemistry. Write down the very first steps of those processes taking into account that proton is involved in the **X**-burning and ^4He in the **Y**-burning. **(2 points)**

2. GLOBAL WARMING (10 points)

Global warming is caused by the greenhouse effect. Three gases, CH_4 , CO_2 and H_2O , are the ones that cause this effect.

1) CH_4 is much more effective for generating the greenhouse effect than the other gases; therefore it is suggested to burn CH_4 before it is released into the atmosphere.

Write and balance the equation between oxygen and CH_4 . **(1 point)**

2) Solving the greenhouse effect requires both reducing the emission of those gases and also retrieving some of the gases already released into the atmosphere. In 2009 30 gigatonnes of CO_2 was released into the atmosphere by burning fossil fuels in addition to 770 gigatonnes released by other processes. Total of 785 gigatonnes was consumed by all processes. $3.6 \cdot 10^{14} \text{ m}^3$ of pure CO_2 was captured from the atmosphere by plants and algae. The concentration of CO_2 in the atmosphere was 385.6 ppmv in the end of 2008.

a) How much did the CO_2 concentration rise in year 2009? Give the answer in ppmv. **(3 points)**

b) Plants and algae convert CO_2 and H_2O into glucose during a process called photosynthesis.

i) Write and balance the chemical equation of photosynthesis. **(1 point)**

ii) How many kg of glucose is produced by plants and algae annually? **(2 points)**

c) How much energy produced from fossil fuels was consumed globally in 2009? **(3 points)**

$1.5 \cdot 10^{18} \text{ J}$ of energy is released per each molecule of CO_2 produced from fossil fuels. Useful constants and formulae: $pV = nRT$, $p = 1 \cdot 10^5 \text{ Pa}$, $R = 8.314 \text{ J}/(\text{mol} \cdot \text{K})$. Volume of the whole atmosphere is $4.2 \cdot 10^9 \text{ km}^3$. Average temperature of the atmosphere is 15°C . ppmv – parts-per million, v refers to volume fraction.



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3. A MIXTURE OF SALTS (9 points)

Excessive dietary intake of sodium has been associated with hypertension and a greater risk of cardiovascular diseases. Many families use low-sodium alternatives, which are a mixture of sodium chloride and other salts. Martin wanted to find out, what is the exact composition of a table salt substitute used by his family. Unfortunately, someone had thrown away the package and Martin did not remember the exact composition or brand of the used substitute. However, he remembered that the substitute consisted of potassium chloride and sodium chloride. As Martin was an excellent chemistry student, he decided to analyze the composition of the mixture. For this, he weighed 3.89 g of the substitute, dissolved it in distilled water and added silver nitrate solution in excess. A white precipitate formed, which weighed 8.20 g after filtration and drying it to a constant mass.

- a) Write reaction equations for the chemical reactions occurring during precipitation. **(1 point)**
- b) Calculate the mass percents of sodium chloride and potassium chloride in the table salt substitute. **(5 points)**

Assume that the substitute consists of only potassium chloride and sodium chloride and the precipitate is water-free and totally insoluble.

Recommended upper limit for daily intake of sodium is 2500 mg for a young person.

- c) How many tablespoons of pure sodium chloride may Martin eat during a year? **(2.5 points)**

1 tablespoon = 5 g of sodium chloride

- d) Offer a possible reason, why using table salt substitutes may not help to significantly reduce sodium intake. **(0.5 points)**

