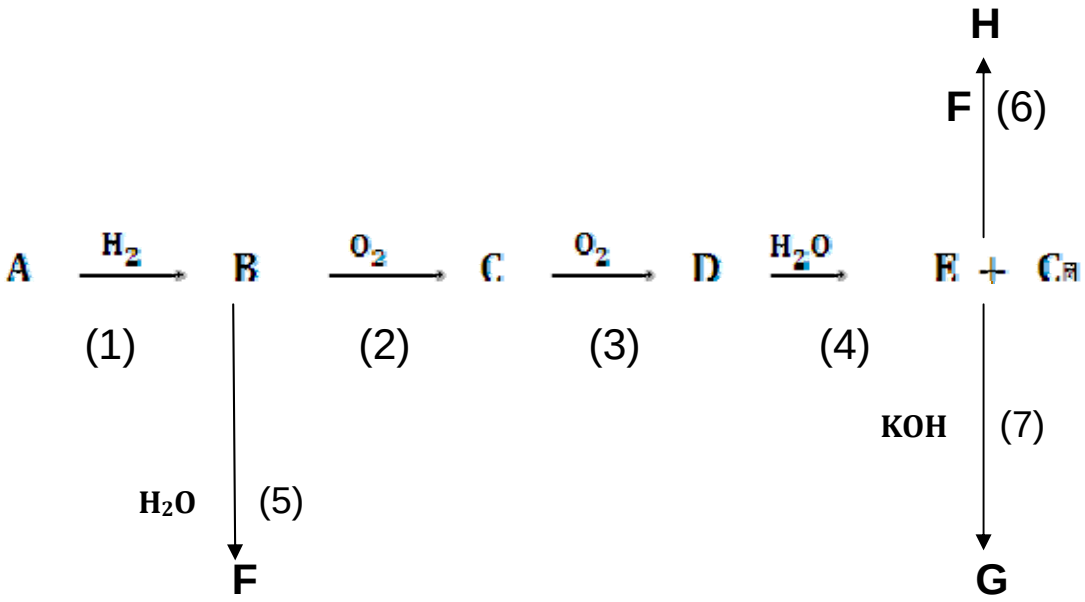
FORM 11

1. (7 points) Element A undergoes the reaction presented below. Only those products that contain element A are presented in the scheme.



- A is an element and can form many different kinds of oxides.
- B is a chemical compound, a gas and very soluble into water.

Write chemical equations for the processes (1) – (7).

2. (9 points) In this problem you can use the following combusting energies for complete burning: glucose 2803 kJ/mol and fat 38 kJ/g

a) In a walking test a person whose weight was 68.0 kg spent oxygen 24.5 ml/kg in a minute (measured in STP conditions). How much energy the person used during the whole test that lasted 16.5 min if all the energy he used came from burning glucose, $C_6H_{12}O_6$?`

b) After all the glucose content in the body is used the body starts to burn fat. How many minutes must the same person as in a) walk to burn 125 g of fat if his need for energy is 0.450 kJ/kg in a minute and all the energy comes from burning fat.

c) Calculate how the consumption of oxygen changes when fat is burning instead of glucose but the need for energy stays the same. A typical fat is glyceryl stearate $C_{57}H_{110}O_6$ (891,5 g/mol). Give the answer in the change of oxygen consumption in percentage?

3. (8 points) Superconducting materials have some very peculiar properties. For example at some temperatures an electrical current can flow through the material without meeting any resistance. Another important property is that a magnetic field cannot penetrate a superconductor, this is called the Meissner effect. The Meissner effect can be seen when a magnet is placed above a superconductor it hovers above it.

One very much used superconductor **A** can be produced letting yttrium oxide, barium carbonate and copper oxide react in the solid state at high temperature (900^{o}C). **A** is composed of 13.4 % of Y, 41.2 % of Ba, 28.6 % of Cu and the remainder is oxygen.

a) Determine the empirical formula for **A.**

b) Calculate the average oxidation state of copper in superconductor **A**. The oxidation state for yttrium in this material is +III.

c) When A is reduced by hydrogen gas at 200 ^{o}C, a compound B and water are formed. As a result of the reduction, the oxidation state of copper changes to +II. The oxidation states of yttrium, barium and oxygen are not changed during the reduction. Calculate the percentage by mass of oxygen in compound **B**.

d) Calculate the mass of **B** obtained from the reduction of 84.2 mg of **A**.

4. (10 points) It is known that the compound **A** is a salt of a common transition metal. Diluted sulfuric acid was dropped on 1.0 g sample of **A** until no further reaction occurred. The products of the reaction were a gas **B** and a nearly colorless solution of **C**. After drying the volume of the gas evolved was 0.211 L (at 25^{o}C and 101.3 kPa) and its weight was 0.38 g.

The solution containing **C** was diluted to 100 ml and treated as follows: A sample of 50 ml of it was titrated with an acidic solution of potassium permanganate with concentration of 0.0200 mol/L. The consumption of permanganate solution was 43.15 mL. When hydrogen peroxide was added to the nearly colorless solution of **C**. The color changed to pale yellow. After that ammonia was added to the solution and it gave a brown precipitate of **D**. This precipitate was filtrated off and solved in diluted hydrochloric acid to yield a yellow solution of **E**. This solution turned to deep red after addition of potassium thiocyanate.

a) Identify compounds **A** to **E**. Show all your calculations and write balanced equations for all reactions.

b) Prove whether really all 1.0 g of **A** reacted. If not please give reasons.

5. (9 points) A laboratory assistant has received a consignment of all six C_4H_8 isomers (which are gases at room temperature). Unfortunately, during shipping the labels have become detached from gas cylinders and she cannot correctly identify them. She labels the cylinders as "**A**" to "**F**" and sets about trying to deduce the contents of each cylinder. She makes the following observations:

i) **A**, **B**, **C** and **D** are seen to decolorize bromine rapidly (even in darkness), while **E** and **F** do not.

ii) The products of the reactions of **B** and **C** with Br_2 are found to be *cis-trans*-isomers of each other.

iii) **A**, **B** and **C** all give identical product when reacted with H_2 over a Pd catalyst.

iv) **E** has a higher boiling point than **F**

v) **C** has a higher boiling point than **B**

Identify the contents of the six cylinders. Give structural formulas and names for the six compounds.