

Each problem is graded from 0 to 10 points. Please write different problem solutions on different paper!

1. Fill the table marking “+” sign if compounds react and “-” sign if they do not react. Write equations for all possible reactions.

Compound	Cl ₂	C ₃ H ₈	C ₂ H ₄	C ₃ H ₄	Ca	CaO	CaCO ₃
CH ₄							
Na							
HCl							
H ₂ O							
H ₂							

2. Experimentally determined that unknown flammable gas does not react with concentrated sulfuric acid. Bubbling this gas through potassium permanganate solution or bromine solution in tetrachloromethane does not lead to color changes. 22.4 mL of this gas at normal conditions (pressure 1 atm, temperature 0°C) weighs 0.058 g.
- Determine what unknown gas is!
 - Write equations for complete and partial combustion of this gas.
 - Calculate mass of barium carbonate that can be obtained if 22.4 mL (normal conditions) of this gas is completely oxidized and reaction products are absorbed in 10 grams 5% barium hydroxide solution. Write equations for all chemical reactions taking place.
3. Alkanes are the simplest organic compounds and they are unreactive comparing to other organic compounds, but they still react with halogens. Halogenation reactions usually proceed till all hydrogen atoms in alkane molecule have been substituted, but this time let's consider monohalogenation reactions with chlorine.
- Write reaction equation for monochlorination reaction of ethane. Name all obtained products and state conditions of reaction!
- If alkane molecule is big enough it contains hydrogen atoms with different reactivity. The most reactive are hydrogen atoms at tertiary positions, while the least reactive are those which are at primary positions. Relative rates of reactivity in chlorination reactions can be expressed as primary : secondary : tertiary positions = 1 : 3.8 : 5.
- Write condensed structural formulas for all possible organic products of monochlorination of 2-methylbutane. Name all organic products.
 - Calculate mass fractions of obtained products, express them in percentage.
 - Draw condensed structural formulas and graphical representations for 2-methylbutane and its' isomers. Name these compounds.
 - State number of different monochlorination products which can form from each isomer of -methylbutane.
 - Order all isomers of 2-methylbutane after increasing boiling points.
4. An investigator studying the residue from an explosion is attempting to identify the explosive and is looking for traces of nitrates, nitrites, sulfates, sulfides, sodium ions and potassium ions. The laboratory report indicates the presence of the ions below. a) NH₄⁺; b) NO₂⁻; c) S²⁻; P³⁻; e) Na⁺.
- Write characteristic reaction for each of determined ions which allows detecting this ion in explosion residue.
 - Suggest one possible composition on explosive using ions determined.
 - Write reaction equation for reaction occurred in explosion.

5. It is known that carbon forms several allotropes. The most popular are diamond, graphite and fullerene.

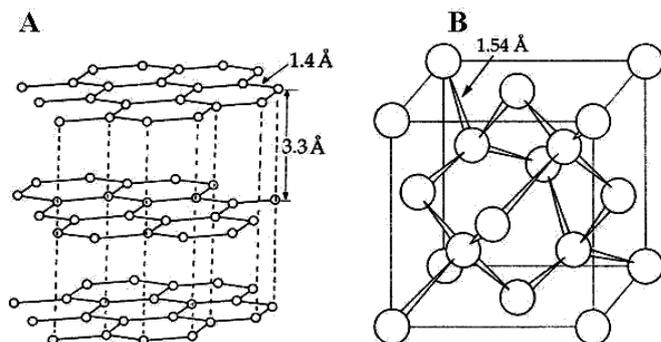
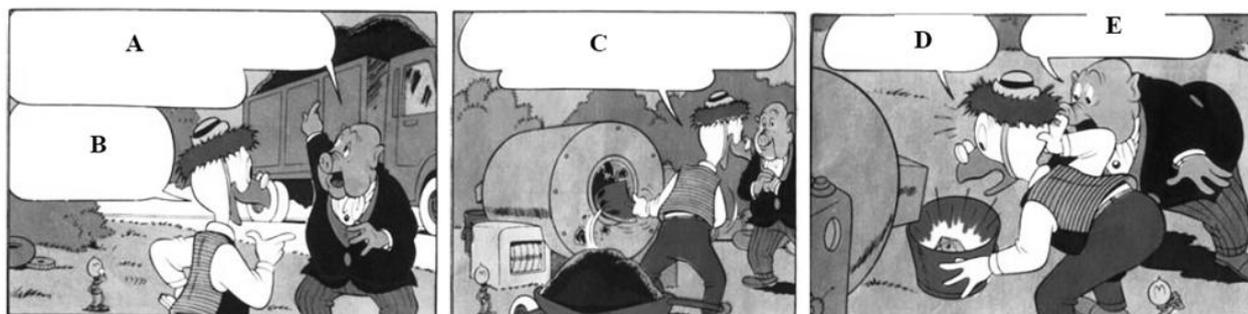


Fig.1. Structures of carbon allotropes, white balls stand for carbon atoms

- Identify to which allotrope correspond structures in figure 1.
- Use data given in figure 1 to calculate crystal density of carbon allotropes A and B.

Approximately fifteen years ago there was story in journal *Mickey Mouse*.



A – Something mysterious! I bought 1000 tons of coal for Disneyland thermal station, but it appeared to be unusable **carbon powder**. They get mucky in fuel burners.

B – O, my God! And I have to find method how to transform it to normal coal?

C – Ok, let's see what I can do. With help of this machine carbon powder will be transformed to normal sized briquettes.

D – O, what is it?

E – It is a **diamond**.

Fig.2. Story form journal "Mickey Mouse"

- Is process described in journal possible? Explain.
- Burning 12.01 grams of carbon powder produces 393.5 kJ of heat while burning 2.50 grams of diamond produces 82.4 kJ of heat. Calculate molar heat of combustion for diamond and carbon powder!
- Using data calculated in 5.d, determine is process carbon powder \rightarrow diamond exothermic or endothermic. Use calculations to justify your answer!
- Is it possible to change conditions of reaction and realize process diamond \rightarrow carbon powder? What could be the best conditions for this reaction?