

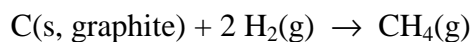
**ENTRANCE EXAMINATION AT THE UNIVERSITIES OF TECHNOLOGY IN
FINLAND (HELSINKI, TAMPERE, LAPPEENRANTA, OULU, ÅBO, TURKU, VAASA)
Chemistry Exam 1 June 2005**

1. A sample contained sodium chloride, NaCl(s) , and calcium chloride, $\text{CaCl}_2\text{(s)}$, and it had a mass of 2.11 g. It was dissolved in water and after that water-soluble sodium carbonate, Na_2CO_3 , was added in to the solution so much that all Ca^{2+} - ions of the solution precipitated as a calcium carbonate precipitate, $\text{CaCO}_3\text{(s)}$. The precipitate was separated by filtering and it was heated until calcium carbonate decomposed to solid calcium oxide and gaseous carbon dioxide. After heating the mass of the oxide precipitate was 0.480 g. What was the mass fraction (%) of CaCl_2 in the original sample?
2. When an aqueous solution of copper sulphate, $\text{CuSO}_4\text{(aq)}$, is electrolyzed the cathode is plated with copper and oxygen gas, $\text{O}_2\text{(g)}$, originating from water is evolved at the anode. It is assumed that copper sulphate is completely dissociated into ions in the aqueous solution.
 - a) Write the reactions that occur at the electrodes and the overall reaction of the electrolysis cell.
 - b) In one experiment, which was done at the pressure of 101 kPa and at the temperature of $20\text{ }^\circ\text{C}$, electrolysis was continued as long as the mass of copper deposited on the cathode was 1.00 g. What quantity of electricity (A s) passed through the electrolysis cell during the experiment?
 - c) What volume of oxygen gas evolved at the anode during the experiment in part b)?
3. For the calibration of the pH meter a buffered solution is prepared by mixing together 0.600 g of acetic acid, CH_3COOH , and 0.738 g of sodium acetate, CH_3COONa , in a volumetric flask which has a volume of 1 dm^3 , and after that filling the flask with water to the mark.
 - a) What is the hydrogen ion concentration in the prepared buffered solution?
 - b) What is the hydroxide ion concentration of the solution?
 - c) What is the pH of the solution?

The acid dissociation constant of acetic acid at room temperature is $1.8 \cdot 10^{-5}\text{ mol dm}^{-3}$ and the ion-product constant of water is $1.0 \cdot 10^{-14}\text{ (mol dm}^{-3}\text{)}^2$. When sodium acetate dissolves in water it dissociates completely into sodium ions and acetate ions from which the acetate ions take part in the ionization reaction of acetic acid.

4. The mass of an evacuated gas vessel made of glass is 27.9214 g. It is filled with dry air to a pressure of 101 kPa at $25\text{ }^\circ\text{C}$ after which the mass of the vessel is 28.0140 g. The vessel is then emptied and filled again under exactly the same conditions with organic hydrocarbon gas. The hydrocarbon gas consists of pure compound that contains only carbon and hydrogen atoms. The mass of the vessel after this new filling is 28.0175 g.
 - a) Calculate the average molar mass of the dry air when it is assumed that it contains 21 mole % oxygen, O_2 , 78 mole % nitrogen, N_2 , and 1 mole % argon, Ar.
 - b) Calculate the molar mass of the organic gas examined.
 - c) What is the compound in question?

5. The enthalpies of formation reactions, where compounds are formed from their elements, have essential significance when the heat of reaction is calculated using thermodynamic tables. At constant pressure the heat of reaction is the same as the enthalpy of reaction. The following formation reaction of methane and the enthalpy of reaction related to it are examined:



- a) What is the molar enthalpy of reaction for this reaction (that is the heat of reaction ΔH when 1 mol of methane is produced) at the pressure of 101 kPa and at the temperature of 25 °C, when the following enthalpies of reaction given under the same conditions are known?
1. $\text{C(s, graphite)} + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$ $\Delta H_1 = -394 \text{ kJ mol}^{-1}$
 2. $\text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$ $\Delta H_2 = -286 \text{ kJ mol}^{-1}$
 3. $\text{CH}_4(\text{g}) + 2 \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{l})$ $\Delta H_3 = -890 \text{ kJ mol}^{-1}$
- b) How much heat is released when 100 g of methane burns completely under these conditions according to reaction 3?
6. a) Draw the structural formula for 3-pentanone. Draw structural formulas of all the aldehydes and ketones that are structural isomers of 3-pentanone and give their names.
- b) Draw the structural formula for 2-methyl-1-propanol. Draw structural formulas of all ethers that are structural isomers of 2-methyl-1-propanol.

Molar masses of the elements:

Element:	H	C	N	O	Na	Cl	Ar	Ca	Cu
M / g mol ⁻¹	1.008	12.01	14.01	16.00	22.99	35.45	39.95	40.08	63.54

Constants:

$$R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1} \quad F = 96490 \text{ A s mol}^{-1}$$