

Descriptive tasks (select at least one)

1. Which factors (and in which way) influence the chemical reaction rate?
2. Describe how to measure the potential of metal/solution interface. Give an example.
Describe the electrode potential scale and reference electrodes.
3. Laws of thermodynamics and their consequences.
4. Describe possible deactivation channels in electronically excited molecules. What are the rates of these processes?
5. Liquid crystal phases. Characteristics and examples of applications.
6. Techniques used for studying surfaces of solids. Give a detailed description of at least one method.
7. Properties of water – what is the main factor responsible for them?
8. Rules governing absorption in NMR, rotational, vibrational and electronic spectra.

Useful constants: $h = 6.626 \cdot 10^{-34} \text{ J}\cdot\text{s}$; $R = 8.314 \text{ J}\cdot\text{K}^{-1}\cdot\text{mol}^{-1}$; $k = 1.38 \cdot 10^{-23} \text{ J}\cdot\text{K}^{-1}$; electron mass = $9.11 \cdot 10^{-31} \text{ kg}$; $c = 2,998 \cdot 10^8 \text{ m/s}$; $1\text{eV} = 1,602 \cdot 10^{-19} \text{ J}$; $F = 96485 \text{ C/mol}$

Short tasks:

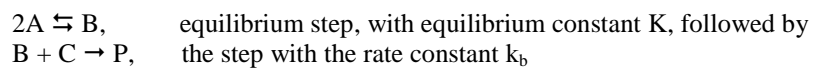
1. Find conditions required for the rate of an enzymatic reaction occurring according to the Michaelis-Menten mechanism to be equal to 50% of its maximum value. It should be recalled that in this mechanism the rate v of formation of the product P from the substrate S in the presence of an enzyme equals $v = d[P]/dt = k_b[S][E]_0/([S]+K_M)$, where k_b is the rate constant of decomposition of the substrate-enzyme complex to the product, $[S]$ is the substrate concentration, $[E]_0$ is the total enzyme concentration, K_M is the Michaelis constant.

2. The enthalpy of melting of mercury is $2.292 \text{ kJ}\cdot\text{mol}^{-1}$, and the normal freezing point is 234.3 K . Molar volume change during melting is $+0.517 \text{ cm}^3\cdot\text{mol}^{-1}$. What is the melting temperature at the base of a 10 m high tube with mercury? The density of mercury is 13.6 g/cm^3 .

3. Calculate the potential of hydrogen electrode in solution of $\text{pH} = 7$ under the pressure of gaseous hydrogen of 0.5 atm at 95 °C. $R = 8.3145 \text{ J/K}\cdot\text{mol}$; $F = 96485 \text{ C/mol}$.

4. The speed of corrosion for magnesium in sea water, expressed by the decrease in mass per time and surface units is $108.9 \text{ g/m}^2\cdot\text{day}$. Express this rate in the units of corrosion current (i_{cor}), assuming that magnesium corrodes according to the reaction $\text{Mg} \rightarrow \text{Mg}^{2+} + 2\text{e}$. $M_{\text{Mg}} = 24.31 \text{ g/mol}$, $F = 96485 \text{ C/mol}$.

5. The reaction of substrates A and C yielding the product P occurs according to the mechanism:



Show that such mechanism leads to a third-order reaction.

6. At the triple point of water (273.16 K) the gaseous thermometer of constant volume, filled with perfect gas, showed a pressure of 50.2 Tr. Calculate:

- What change of pressure corresponds to a change in temperature by 1 K,
- What pressure corresponds to a temperature of 100.00 °C,
- What change of pressure corresponds to a change in temperature by 1 K at 100 °C.

7. A proton moving with certain velocity has a wavelength of 1 mm. What wavelength corresponds to the following objects moving with the same velocity (a) electron; (b) water molecule (c) a molecule of ammonia (the ratio of proton to electron mass is 1833).

8. Show the order of increasing energy for the quanta of radiation used in: (a) electronic; (b) vibrational; (c) rotational; (d) NMR (e) photoelectron (XPS) spectroscopy.

9. Calculate the activation energy of a reaction for which the rate is tripled by raising the temperature from 150 to 175°C.

10. What is the coordination number and the packing fraction for a primitive cubic system, in which the nodal points are located at the vertices of a cube?

11. Show the proper ordering (toward larger values) of the ionization energies for: (a) Al; (b) Na; (c) Ar; (d) S

12. Calculate the distance between the adjacent (123) planes of a rhombic crystal with the following unit cell parameters: $a = 0.82 \text{ nm}$, $b = 0.94 \text{ nm}$, $c = 0.75 \text{ nm}$.

13. Assign corresponding symmetry elements to three molecules:

Symmetry elements: (1): three C_2 axes, three mirror planes, inversion centre; (2) one C_2 axis, two mirror planes;

(3) a threefold axis, three diagonal planes

Molecules: (a) chlorobenzene (b) ethylene (c) trifluoromethane

14. Calculate the change in molar entropy for bromine, when it is transferred, under a constant pressure of 1 atm from the crystalline state at the melting point of $-7,32\text{ }^\circ\text{C}$ into saturated vapour at the boiling temperature of $58,80\text{ }^\circ\text{C}$.

Average heat capacity of liquid bromine is $0,447\text{ J/g }^\circ\text{C}$

Molar heat of melting: $10,813\text{ kJ/mol}$

Molar heat of vaporization: $29,189\text{ kJ/mol}$

Atomic weight of bromine: $79,916$

15. Give examples of molecules of which the vibrations will be (a) simultaneously active in both IR and Raman spectra; (b) only in Raman; (c) either in IR or in Raman

16. 10 g of thallium was inserted into a solution of copper(II). Thallium dissolved, and the mass of copper deposited from the solution was 1.555 g. What is the charge of thallium ions in this solution? $M_{\text{Tl}} = 204.37$ g/mol, $M_{\text{Cu}} = 63.546$ g/mol.