| Department of Mathematics/Faculty of Nuclear Sciences and Physical Engineering | |
|---|---|
| Name and Surname of Candidate | Passport Number |

# Entrance examination in mathematics

example

Mathematical Engineering

**1** (6 points) Solve the following differential equation

$$y'' - 2y' + 10y = 27x\mathrm{e}^x$$

together with conditions $y(0) = -2$ a $y'(0) = 1$.

**2** (2 points) Calculate Wronskian (Wronski Determinant) for functions $\mathrm{e}^{-2x}, x\mathrm{e}^{-2x}, x^2\mathrm{e}^{-2x}$. Are these functions linearly dependent or not? Explain.

**3** (5 points) Create a Taylor's series of the function $g(x) = \mathrm{e}^{3x}$ centered to the point $x = 0$. For which $x$ the Taylor's series is convergent? Use the result to determine the sum of the following series:

$$\sum_{k=0}^{\infty} (-1)^k \frac{x^{2k+1}}{4^k k!}.$$

**4** (10 points) Let

$$A = \left\{(x, y) \in \mathbb{R}^2 : \left(\frac{x^2}{a^2} + \frac{y^2}{b^2}\right)^4 \leqslant \frac{2xy}{ab}\right\}.$$

be a two-dimensional area and $a, b$ be positive parameters. By means of the mapping $x = ar\cos(\varphi)$, $y = br\sin(\varphi)$, calculate the integral $\int_A x^2y^2 \, \mathrm{d}(x, y)$.

**5** (2 points) Find sum and product of all eigenvalues of the matrix $\mathbb{H} = \begin{pmatrix} 5 & -2 & 0 \\ -2 & 1 & 0 \\ 0 & 0 & 4 \end{pmatrix}$.

**6** (5 points) For which $x$ the series $\sum_{n=1}^{\infty} \left(\frac{2^n}{n} + \frac{3^n}{n^2}\right) x^n$ is convergent?

**7** (4 points) Let $X$ be a linear normed space and $f : X \to \mathcal{R}$ a mapping given by $f(x) = \|x\|, \ x \in X$. Prove its continuity.

**8** (6 points) Solve the differential equation

$$2xy - 2x + (x^2 + 3)y' = 0$$

with the initial condition $y(1) = 2$.

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The admission exam is considered successful if the candidate has at least **20** points.

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# Entrance examination in mathematics

example

Applied Algebra and Analysis

**1** (6 points) Solve the following differential equation

$$y'' - 2y' + 10y = 27x\mathrm{e}^{x}$$

together with conditions $y(0) = -2$ a $y'(0) = 1$.

**2** (2 points) Calculate Wronskian (Wronski Determinant) for functions $\mathrm{e}^{-2x}, x\mathrm{e}^{-2x}, x^2\mathrm{e}^{-2x}$. Are these functions linearly dependent or not? Explain.

**3** (5 points) Create a Taylor's series of the function $g(x) = \mathrm{e}^{3x}$ centered to the point $x = 0$. For which $x$ the Taylor's series is convergent? Use the result to determine the sum of the following series:

$$\sum_{k=0}^{\infty} (-1)^k \frac{x^{2k+1}}{4^k k!}.$$

**4** (10 points) Let

$$A = \left\{ (x, y) \in \mathbb{R}^2 : \left( \frac{x^2}{a^2} + \frac{y^2}{b^2} \right)^4 \leqslant \frac{2xy}{ab} \right\}.$$

be a two-dimensional area and $a, b$ be positive parameters. By means of the mapping $x = ar\cos(\varphi)$, $y = br\sin(\varphi)$, calculate the integral $\int_A x^2y^2 \,\mathrm{d}(x, y)$.

**5** (2 points) Find sum and product of all eigenvalues of the matrix $\mathbb{H} = \begin{pmatrix} 5 & -2 & 0 \\ -2 & 1 & 0 \\ 0 & 0 & 4 \end{pmatrix}$.

**6** (5 points) For which $x$ the series $\sum_{n=1}^{\infty} \left( \frac{2^n}{n} + \frac{3^n}{n^2} \right) x^n$ is convergent?

**7** (5 points) Find Fourier transformation of function

$$f(x) = \begin{cases} x - 2, & 2 \leq x \leq 3, \\ 4 - x, & 3 \leq x \leq 4, \\ 0 & x < 2 \text{ nebo } x > 4. \end{cases}$$

**8** (5 points) Find a solution of heat equation problem:

$$\begin{aligned} &u_t = u_{xx}, \quad 0 < x < 1,\ t > 0 \\ &u(0, t) = u(1, t) = 0, \\ &u(x, 0) = x^2 - 1. \end{aligned}$$

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The admission exam is considered successful if the candidate has at least **20** points.

| Department of Mathematics/Faculty of Nuclear Sciences and Physical Engineering | |
|---|---|
| Name and Surname of Candidate | Passport Number |

# Entrance examination in mathematics

example

Mathematical informatics

**1** (6 points) Solve the following differential equation

$$y'' - 2y' + 10y = 27x\mathrm{e}^x$$

together with conditions $y(0) = -2$ a $y'(0) = 1$.

**2** (2 points) Calculate Wronskian (Wronski Determinant) for functions $\mathrm{e}^{-2x}, x\mathrm{e}^{-2x}, x^2\mathrm{e}^{-2x}$. Are these functions linearly dependent or not? Explain.

**3** (5 points) Create a Taylor's series of the function $g(x) = \mathrm{e}^{3x}$ centered to the point $x = 0$. For which $x$ the Taylor's series is convergent? Use the result to determine the sum of the following series:

$$\sum_{k=0}^{\infty} (-1)^k \frac{x^{2k+1}}{4^k k!}.$$

**4** (10 points) Let

$$A = \left\{ (x, y) \in \mathbb{R}^2 : \left( \frac{x^2}{a^2} + \frac{y^2}{b^2} \right)^4 \leqslant \frac{2xy}{ab} \right\}.$$

be a two-dimensional area and $a, b$ be positive parameters. By means of the mapping $x = ar\cos(\varphi)$, $y = br\sin(\varphi)$, calculate the integral $\int_A x^2y^2 \,\mathrm{d}(x, y)$.

**5** (2 points) Find sum and product of all eigenvalues of the matrix $\mathbb{H} = \begin{pmatrix} 5 & -2 & 0 \\ -2 & 1 & 0 \\ 0 & 0 & 4 \end{pmatrix}$.

**6** (5 points) For which $x$ the series $\sum_{n=1}^{\infty} \left( \frac{2^n}{n} + \frac{3^n}{n^2} \right) x^n$ is convergent?

**7** (5 points) Let $G = \left\{ \left( \begin{smallmatrix} a & b \\ c & d \end{smallmatrix} \right) : a, b, c, d \in \mathbb{Z} \text{ a } \det \left( \begin{smallmatrix} a & b \\ c & d \end{smallmatrix} \right) = 1 \right\}$. Show that $G$ equipped with the standard matrix multiplication is a group. What can be said about the eigenvalues of a matrix $M \in G$ if the order of $M$ in $G$ is equal to a given positive integer $k$. Find in $G$ (if it exists) an element of order 2, an element of order 4, and an element of order $+\infty$.

**8** (5 points) Given the ring $\mathbb{Z}[i] := \{a + ib : a, b \in \mathbb{Z}\}$, where $i$ is the imaginary unit and the operations $+$ and $\times$ are defined as in the field $\mathbb{C}$ of complex numbers. Denote $\beta = i - 1 \in \mathbb{Z}[i]$. We say that $x \in \mathbb{Z}[i]$ is related to $y \in \mathbb{Z}[i]$ and write $x \sim y$, if there exists $w \in \mathbb{Z}[i]$ such that $x - y = \beta w$. Show that $\sim$ is an equivalence relation on $\mathbb{Z}[i]$. Decide whether $2i \sim 2 + i$.

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The admission exam is considered successful if the candidate has at least **20** points.

| Department of Mathematics/Faculty of Nuclear Sciences and Physical Engineering | |
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# Entrance examination in mathematics

example

Applied Mathematical Stochastic Methods

**1** (6 points) Solve the following differential equation

$$y'' - 2y' + 10y = 27x\mathrm{e}^{x}$$

together with conditions $y(0) = -2$ a $y'(0) = 1$.

**2** (2 points) Calculate Wronskian (Wronski Determinant) for functions $\mathrm{e}^{-2x}, x\mathrm{e}^{-2x}, x^2\mathrm{e}^{-2x}$. Are these functions linearly dependent or not? Explain.

**3** (5 points) Create a Taylor's series of the function $g(x) = \mathrm{e}^{3x}$ centered to the point $x = 0$. For which $x$ the Taylor's series is convergent? Use the result to determine the sum of the following series:

$$\sum_{k=0}^{\infty}(-1)^k \frac{x^{2k+1}}{4^k k!}.$$

**4** (10 points) Let

$$A = \left\{(x,y) \in \mathbb{R}^2 : \left(\frac{x^2}{a^2} + \frac{y^2}{b^2}\right)^4 \leqslant \frac{2xy}{ab}\right\}.$$

be a two-dimensional area and $a, b$ be positive parameters. By means of the mapping $x = ar\cos(\varphi)$, $y = br\sin(\varphi)$, calculate the integral $\int_A x^2y^2\,\mathrm{d}(x,y)$.

**5** (2 points) Find sum and product of all eigenvalues of the matrix $\mathbb{H} = \begin{pmatrix} 5 & -2 & 0 \\ -2 & 1 & 0 \\ 0 & 0 & 4 \end{pmatrix}$.

**6** (5 points) For which $x$ the series $\sum_{n=1}^{\infty}\left(\frac{2^n}{n} + \frac{3^n}{n^2}\right)x^n$ is convergent?

**7** (5 points) Calculate the standard deviation of random variable described by probability density $g(x) = 16\Theta(x)x\mathrm{e}^{-4x}$, where $\Theta(x)$ is Heaviside unit-step function

$$\Theta(x) = \begin{cases} 0 & x \leqslant 0; \\ 1 & x > 0. \end{cases}$$

**8** (5 points) Find a probability density function of two independent and identically distributed random variables $\mathcal{X}, \mathcal{Y}$ so that the sum $\mathcal{X} + \mathcal{Y}$ is exponentially distributed via probability density function $4\Theta(x)\mathrm{e}^{-4x}$. Advice: Use Laplace transform.

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The admission exam is considered successful if the candidate has at least **20** points.

# Entrance Examination in Physics for the Master Continuation Programmes

**SAMPLE TEST with answers**

**Branches: Mathematical Physics, Nuclear and Particle Physics, Quantum Technologies**

The entrance examination is regarded as successful, if the candidate has obtained at least 20 points (i.e. 50% of the maximum score).

1. A particle's movement is governed by parametric equations $x = at$, $y = bt$ with $a, b$ constant. Determine the radial and transverse components of the velocity and acceleration vectors of the movement.

   (4 points)

   Answer: $v_r = \dot{r} = \sqrt{a^2 + b^2}$, $v_\varphi = r\dot{\varphi} = 0$, $a_r = \ddot{r} - r\dot{\varphi}^2$, $a_\varphi = 2\dot{r}\dot{\varphi} + r\ddot{\varphi} = 0$

2. A simple pendulum of mass $m$ and length $l$ is at time $t = 0$ displaced by angle $\varphi_0$ from the vertical and released. Determine the maximum tension in the string and velocity at the equilibrium position.

   (4 points)

   Answer: $F = mg(3 - 2\cos\varphi_0)$, $v = \sqrt{2gl(1 - \cos\varphi_0)}$

3. A cart loaded with sand moves along a horizontal road due to a constant horizontal force $F$. Sand spills through a hole in the bottom with a constant rate per time $\mu$. At time $t = 0$ was the cart's velocity zero and the cart loaded with sand had the mass $M$. Determine the speed and acceleration of the cart.

   (5 points)

   Answer: $a = \frac{F}{M - \mu t}$, $v = \frac{F}{\mu} \ln \frac{M}{M - \mu t}$

4. A spaceship moves with speed $v_1 = 0.8c$ relative to Earth and fires a rocket in the forward direction at a speed $v_2 = 0.6c$ relative to the spaceship. The proper length of the rocket is $l_0 = 10m$. Determine the length of the rocket measured by the observer on the spaceship and by the observer on Earth.

   (4 points)

   Answer: $l_{v_1} = 8m$, $l_{v_2} = 3.24m$

5. Determine the magnitude of the electric field $E$ at the centre of a hemispherical shell with radius $R$ and uniform surface charge density $\sigma$.

   (5 points)

   Answer: $E = \frac{\sigma}{4\varepsilon_0}$

6. Determine the leakage resistance of a spherical capacitor with the radii of its metal shells $R_1 < R_2$. The space between the spherical shells is filled with oil of resistivity $\varrho$.

   (5 points)

   $\boxed{\text{Answer:}}$ $R = \frac{\varrho}{4\pi} \frac{R_2 - R_1}{R_1 R_2}$

7. Determine the force on a charged particle that is moving with velocity $v = E/B$ in mutually perpendicular electric and magnetic fields. The vectors $\vec{E}$, $\vec{B}$, $\vec{v}$ form a right-handed orthogonal system.

   (4 points)

   $\boxed{\text{Answer:}}$ $\vec{F} = \vec{0}$

8. Determine natural frequency of longitudinal vibrations of a mass point that is connected to fixed points by two springs with equal spring constants $k$.

   (4 points)

   $\boxed{\text{Answer:}}$ $\omega = \sqrt{\frac{2k}{m}}$

9. Determine the Lagrangian $L(\varphi, \dot{\varphi}, t)$ and derive the equation of motion of a simple pendulum with extensible length $l$ which increases as $l(t) = l_0(1 + kt)$, where $l_0$ and $k$ are constant.

   (5 points)

   $\boxed{\text{Answer:}}$ $L(\varphi, \dot{\varphi}, t) = \frac{1}{2} m \left( \dot{l}^2 + l^2 \dot{\varphi}^2 \right) + mgl \cos\varphi$, $(1 + kt)\ddot{\varphi} + 2k\dot{\varphi} + \frac{g}{l_0} \sin\varphi = 0$

# Entrance Examination in Physics for the Master Continuation Programmes

**SAMPLE TEST with answers**

**Branches: Physical Electronics, Nuclear Engineering, Solid State Engineering, Physical Engineering of Materials, Plasma Physics and Thermonuclear Fusion**

The entrance examination is regarded as successful, if the candidate has obtained at least 20 points (i.e. 50% of the maximum score).

1. A particle's movement is governed by parametric equations $x = at$, $y = bt$ with $a, b$ constant. Determine the radial and transverse components of the velocity and acceleration vectors of the movement.

   (4 points)

   Answer: $v_r = \dot{r} = \sqrt{a^2 + b^2}$, $v_\varphi = r\dot{\varphi} = 0$, $a_r = \ddot{r} - r\dot{\varphi}^2$, $a_\varphi = 2\dot{r}\dot{\varphi} + r\ddot{\varphi} = 0$

2. A simple pendulum of mass $m$ and length $l$ is at time $t = 0$ displaced by angle $\varphi_0$ from the vertical and released. Determine the maximum tension in the string and velocity at the equilibrium position.

   (4 points)

   Answer: $F = mg(3 - 2\cos\varphi_0)$, $v = \sqrt{2gl(1 - \cos\varphi_0)}$

3. A cart loaded with sand moves along a horizontal road due to a constant horizontal force $F$. Sand spills through a hole in the bottom with a constant rate per time $\mu$. At time $t = 0$ was the cart's velocity zero and the cart loaded with sand had the mass $M$. Determine the speed and acceleration of the cart.

   (5 points)

   Answer: $a = \frac{F}{M - \mu t}$, $v = \frac{F}{\mu} \ln \frac{M}{M - \mu t}$

4. A spaceship moves with speed $v_1 = 0.8c$ relative to Earth and fires a rocket in the forward direction at a speed $v_2 = 0.6c$ relative to the spaceship. The proper length of the rocket is $l_0 = 10m$. Determine the length of the rocket measured by the observer on the spaceship and by the observer on Earth.

   (4 points)

   Answer: $l_{v_1} = 8m$, $l_{v_2} = 3.24m$

5. Determine the magnitude of the electric field $E$ at the centre of a hemispherical shell with radius $R$ and uniform surface charge density $\sigma$.

   (5 points)

   Answer: $E = \frac{\sigma}{4\varepsilon_0}$

6. Determine the leakage resistance of a spherical capacitor with the radii of its metal shells $R_1 < R_2$. The space between the spherical shells is filled with oil of resistivity $\varrho$.

   (5 points)

   $\boxed{\text{Answer:}}$ $R = \frac{\varrho}{4\pi} \frac{R_2 - R_1}{R_1 R_2}$

7. Determine the force on a charged particle that is moving with velocity $v = E/B$ in mutually perpendicular electric and magnetic fields. The vectors $\vec{E}$, $\vec{B}$, $\vec{v}$ form a right-handed orthogonal system.

   (4 points)

   $\boxed{\text{Answer:}}$ $\vec{F} = \vec{0}$

8. Determine natural frequency of longitudinal vibrations of a mass point that is connected to fixed points by two springs with equal spring constants $k$.

   (4 points)

   $\boxed{\text{Answer:}}$ $\omega = \sqrt{\frac{2k}{m}}$

9. Determine the average speed $\langle v \rangle$ for the Maxwell–Boltzmann distribution of speeds.

   (5 points)

   $\boxed{\text{Answer:}}$ $\langle v \rangle = \sqrt{\frac{8kT}{\pi m}}$

# Entrance Examination in Physics for the Master Continuation Programmes

$\boxed{\text{SAMPLE TEST with answers}}$

**Branch: Decommissioning of Nuclear Facilities**

The entrance examination is regarded as successful, if the candidate has obtained at least 20 points (i.e. 50% of the maximum score).

1. A particle's movement is governed by parametric equations $x = at$, $y = bt$ with $a, b$ constant. Determine the radial and transverse components of the velocity and acceleration vectors of the movement.

   (4 points)

   $\boxed{\text{Answer:}}$ $v_r = \dot{r} = \sqrt{a^2 + b^2}$, $v_\varphi = r\dot{\varphi} = 0$, $a_r = \ddot{r} - r\dot{\varphi}^2$, $a_\varphi = 2\dot{r}\dot{\varphi} + r\ddot{\varphi} = 0$

2. A simple pendulum of mass $m$ and length $l$ is at time $t = 0$ displaced by angle $\varphi_0$ from the vertical and released. Determine the maximum tension in the string and velocity at the equilibrium position.

   (4 points)

   $\boxed{\text{Answer:}}$ $F = mg(3 - 2\cos\varphi_0)$, $v = \sqrt{2gl(1 - \cos\varphi_0)}$

3. A cart loaded with sand moves along a horizontal road due to a constant horizontal force $F$. Sand spills through a hole in the bottom with a constant rate per time $\mu$. At time $t = 0$ was the cart's velocity zero and the cart loaded with sand had the mass $M$. Determine the speed and acceleration of the cart.

   (5 points)

   $\boxed{\text{Answer:}}$ $a = \frac{F}{M-\mu t}$, $v = \frac{F}{\mu} \ln \frac{M}{M-\mu t}$

4. A spaceship moves with speed $v_1 = 0.8c$ relative to Earth and fires a rocket in the forward direction at a speed $v_2 = 0.6c$ relative to the spaceship. The proper length of the rocket is $l_0 = 10m$. Determine the length of the rocket measured by the observer on the spaceship and by the observer on Earth.

   (4 points)

   $\boxed{\text{Answer:}}$ $l_{v_1} = 8m$, $l_{v_2} = 3.24m$

5. Determine the magnitude of the electric field $E$ at the centre of a hemispherical shell with radius $R$ and uniform surface charge density $\sigma$.

   (5 points)

   $\boxed{\text{Answer:}}$ $E = \frac{\sigma}{4\varepsilon_0}$

6. Determine the leakage resistance of a spherical capacitor with the radii of its metal shells $R_1 < R_2$. The space between the spherical shells is filled with oil of resistivity $\varrho$.

   (5 points)

   $\boxed{\text{Answer:}}$ $R = \frac{\varrho}{4\pi}\frac{R_2 - R_1}{R_1 R_2}$

7. Determine the force on a charged particle that is moving with velocity $v = E/B$ in mutually perpendicular electric and magnetic fields. The vectors $\vec{E}$, $\vec{B}$, $\vec{v}$ form a right-handed orthogonal system.

   (4 points)

   $\boxed{\text{Answer:}}$ $\vec{F} = \vec{0}$

8. A wire of constant resistivity is bent in the form of an equilateral triangle. Two vertices of the triangle are connected to a source of electromotive force $\mathcal{E}$. Determine the magnetic field in the centre of the triangle.

   (4 points)

   $\boxed{\text{Answer:}}$ $\vec{B} = \vec{0}$

9. A square loop with side length $a$ rotates in the uniform magnetic field $\vec{B}$ around axis parallel with the loop plane and perpendicular to the field with constant angular velocity $\omega$. At time $t = 0$ is the loop in the plane perpendicular to the field. Determine the induced electromotive force $\mathcal{E}$ at time $t$.

   (5 points)

   $\boxed{\text{Answer:}}$ $\mathcal{E} = Ba^2\omega \sin \omega t$

Test in chemistry for the follow-up master's study

Model test with results

Study field: Nuclear chemistry

The exam is considered to have been successfully passed if the candidate has obtained at least 20 points (i.e. 50 % of the maximum number of points).

1. The density of a natural isotopic mixture of unknown gas at a temperature of 293.15 K and a pressure of 101325 Pa is $\rho$ = 1330.1 g.m$^{-3}$. What gas is it? Assume ideal gas behavior.
   (4 points)
   Result: It's oxygen.

2. An important product of the chemical processing of uranium ores is insoluble diammonium diuranate, which precipitates from uranyl sulfate solution via ammonia solution. Write the stoichiometric equation of the reaction. For the purposes of stoichiometry, aqueous ammonia solution may be regarded as "ammonium hydroxide".
   (4 points)
   Result: $2\ (UO_2)SO_4 + 6\ NH_4OH \rightarrow (NH_4)_2U_2O_7 + 2\ (NH_4)_2SO_4 + 3\ H_2O$

3. Fill in the missing substance marked with a question mark in the equation *(c)* and determine the stoichiometric coefficients:
   a) $Ag + O_2 + KCN + H_2O \rightarrow K[Ag(CN)_2] + KOH$
   b) $Cr_2O_3 + NaNO_3 + Na_2CO_3 \rightarrow Na_2CrO_4 + NaNO_2 + CO_2$
   c) $MnO_2 + KClO_3 + KOH \rightarrow K_2MnO_4 + KCl + ?$
   d) $Fe_2O_3 + KNO_3 + KOH \rightarrow K_2FeO_4 + KNO_2 + H_2O$
   (4 points)
   Result:
   a) $4\ Ag + O_2 + 8\ KCN + 2\ H_2O \rightarrow 4\ K[Ag(CN)_2] + 4\ KOH$
   b) $Cr_2O_3 + 3\ NaNO_3 + 2\ Na_2CO_3 \rightarrow 2\ Na_2CrO_4 + 3\ NaNO_2 + 2\ CO_2$
   c) $3\ MnO_2 + KClO_3 + 6\ KOH \rightarrow 3\ K_2MnO_4 + KCl + 3\ H_2O$
   d) $Fe_2O_3 + 3\ KNO_3 + 4\ KOH \rightarrow 2\ K_2FeO_4 + 3\ KNO_2 + 2\ H_2O$

4. Substance A with an unknown molar concentration of $c_1$ is dissolved in the solution. 2 mL of this solution were made up with distilled water to a total volume of $V$ = 100 mL. For analysis, a 500 $\mu$L sample was taken from the diluted solution, which was made up to the mark with distilled water in a 10 mL volumetric flask. The concentration of substance A in the sample thus prepared was $C_3$ = 3.8.10$^{-4}$ mol.L$^{-1}$. What was the concentration of substance $c_1$ in the starting solution?
   (4 points)
   Result: $c_1$ = 0.38 mol.L$^{-1}$

5. Oxidation of copper with nitric acid proceeds according to the following equation:
   $3\ Cu + 8\ HNO_3 \rightarrow 3\ Cu(NO_3)_2 + 2\ NO + 4\ H_2O$.
   What must be the mass of copper introduced into the reaction if the amount of $Cu(NO_3)_2$ is to be equal to 0.75 mol? What volume of $HNO_3$ solution with a density of 1376.9 g.L$^{-1}$ and a weight fraction of 0.62 should be used, and what will be the volume of NO formed under normal conditions (T = 273.15 K, P = 101325 Pa)?
   (4 points)
   Result: 47.7 g; 148 mL; 11.2 dm$^3$

6. The standard heat of combustion of methane during the formation of liquid water is equal to -891 $kJ.moL^{-1}$. Assume that we have burned in excess oxygen *a)* 1 g of methane, *b)* such an amount of methane, the volume of which at a temperature of 25 ° C and a pressure of 0.0987 MPa is just $1 \cdot 10^{-3}$ $dm^3$. Calculate how much heat $\Delta H$ the reaction system transfers to the surroundings in both cases.
   (5 points)
   Result: a) -55.5 kJ; b) -0.035 kJ

7. The equilibrium degree of conversion of ethane in the reaction $C_2H_6$ (g) ↔ $C_2H_4$ (g) + $H_2$ (g) at a temperature of 1000 K was $\alpha$ = 0.485. The equilibrium system pressure was equal to the standard pressure. Pure ethane was introduced into the reaction and the reaction mixture behaved ideally. Calculate the value of the equilibrium constant $K_a$ at the given temperature and the molar fractions of the components in the equilibrium mixture.
   (5 points)
   Result: $K_a$ = 0.308; $x$ ($C_2H_6$) = 0.341; $x$ ($C_2H_4$) = $x$ ($H_2$) = 0.327

8. Calculate the pH of these aqueous solutions: *a)* KOH solution with a total (analytical) concentration of $5 \cdot 10^{-4}$ $mol.L^{-1}$; *b)* HCl solution with a total concentration of $2 \cdot 10^{-8}$ $mol.L^{-1}$. Can activity coefficients be considered as unit? Use the value of the ionic product of water $K_W$ = $1.01 \cdot 10^{-14}$.
   (5 points)
   Result: pH(KCl) = 10.69; pH(HCl) = 6.96

9. The reaction 2 HI → $H_2$ + $I_2$ belongs at temperatures 629 K and 700 K to the rate constant $3 \cdot 10^{-5}$ and $1.2 \cdot 10^{-3}$ $L.mol^{-1}.s^{-1}$, resp. Calculate the value of the activation energy and the frequency factor.
   (5 points)
   Result: $E_a$ = 190.2 $kJ.mol^{-1}$; $A$ = $1.9 \cdot 10^{11}$ $L.mol^{-1}.s^{-1}$