Chemistry & Materials Science: second-round sample tasks

There are 30 tasks in the test: 18 entry-level tasks with a single correct answer (each is worth 1 point), nine intermediate tasks with multiple correct answers (each task worth 4-6 points) and three advanced constructed response tasks (each correct and detailed answer is worth 10-14 points). Correct answers are given in **bold.**

Choose the correct answer:

Section 1. General and inorganic chemistry

Entry-level tasks (each correct answer - 1 point)

Task 1. The length of the hydrogen cyanide molecule is $6.04 \cdot 10^{-11}$ m. Calculate the dipole moment of the molecule (D) of 1D = $3.33 \cdot 10^{-30}$ Kl·m.

A) 1.45

B) 2.9

C) $3.33 \cdot 10^{-20}$

D) $9.66 \cdot 10^{-30}$

Task 2. Calculate the ionic strength of 0.05 M $MgCl_2$ solution.

A) 0.125

B) 0.1

C) 0.15

D) 0.075

Task 3. A galvanic cell consists of metallic zinc immersed in 0.01 M zinc nitrate solution and metallic copper immersed in 1 M copper nitrate solution. Calculate the EMF of the galvanic cell. Standard potentials: φ^0 (Zn^{2+}/Zn) = -0.76B, φ^0 (Cu^{2+}/Cu) = 0.34 B.

A) 1.1 B

B) –0.42 B

C) –0.48 B

D) 1.16 B

Intermediate-level task (6 points)

Task 4. Which **THREE** of the following enhance the hydrolysis of potassium acetate,

A) addition of sodium sulfate to the solution

B) temperature increase

C) a decrease in the concentration of potassium acetate

D) pressure reduction

E) addition of hydrochloric acid to the solution

F) increase in pressure

Points awarded:

6 points for three correct answers

4 points for two correct answers

2 points for one correct answer

<u>Advanced-level task (14 points)</u>

Task 5. 50 ml of 0.02 mol/l potassium iodide solution was added to 200 ml of 0.001 mol/l mercury (II) nitrate solution. If 150 ml of 0.002 mol / l sodium sulfide solution is added to the resulting solution, will a precipitate fall out? The value of the solubility product of mercury (II) sulfide is 10^{-52}. Ignore the losses. Confirm your answer with calculations.

Solution:

$Hg(NO_3)_2 + 4KI = K_2[HgI_4] + 2KNO_3$

$K_2[HgI_4] + Na_2S = HgS + 2KI + 2NaI$

n(Hg(NO3)2) = c·V = 0.2 l·0.001 mol/l = 0.0002 mol

n(KI) = c·V = 0.05 l·0.02 mol/l = 0.001 mol – excess

$n(K_2[HgI_4])$ = n(Hg(NO3)2) = 0.0002 mol

After reaction 1:

V solution = 200 ml +50 ml = 250 ml = 0.25 l

$n(K_2[HgI_4])$ = 0.0002 mol

$n(Na_2S)$ = c·V = 0.15 l·0.002 mol/l = 0.0003 mol – excess

n(HgS) = n(K2[HgI4]) = 0.0002 mol

After reaction 2:

V solution = 250 ml + 150 ml = 400 ml = 0.4 l

$n(Hg^{2+})$ = n(HgS) = 0.0002 mol

$n(S^{2-})$ = n(HgS) = 0.0002 mol

$c(Hg^{2+}) = \frac{n}{V} = \frac{0.0002}{0.4} = 0.0005$ mol/l

$c(S^{2-}) = \frac{n}{V} = \frac{0.0002}{0.4} = 0.0005$ mol/l

product of solubility = $[Hg^{2+}] \cdot [S^{2-}] = 0.0005 \cdot 0.0005 = 2.5 \cdot 10^{-7}$

$2.5 \cdot 10^{-7}$ □ product of solubility; a precipitate will fall out.

Assessment criteria (alternative formulations are acceptable as long as the answer is correct).	**Points**
$Hg(NO_3)_2 + 4KI = K_2[HgI_4] + 2KNO_3$ $K_2[HgI_4] + Na_2S = HgS + 2KI + 2NaI$	2
n(Hg(NO3)2) = c·V = 0.2 l·0.001 mol/l = 0.0002 mol n(KI) = c·V = 0.05 l·0.02 mol/l = 0.001 mol $n(Na_2S)$ = c·V = 0.15 l·0.002 mol/l = 0.0003 mol	3 (3*1)
$n(K_2[HgI_4])$ = n(Hg(NO3)2) = 0.0002 mol n(HgS) = n(K2[HgI4]) = 0.0002 mol	2 (2*1)
$n(Hg^{2+})$ = n(HgS) = 0.0002 mol $n(S^{2-})$ = n(HgS) = 0.0002 mol	2(2*1)
$c(Hg^{2+}) = \frac{n}{V} = \frac{0,0002}{0,4} = 0.0005$ mol/l $c(S^{2-}) = \frac{n}{V} = \frac{0,0002}{0,4} = 0.0005$ mol/l	2 (2*1)
product of solubility = $[Hg^{2+}] \cdot [S^{2-}] = 0.0005 \cdot 0.0005 = 2.5 \cdot 10^{-7}$	2
A precipitate falls out.	1
Maximum score	**14**

Section 2. Physical chemistry

Entry-level tasks (each correct answer - 1 point)

Task 6. (Topic: second and third law of thermodynamics)
Calculate the mass of helium involved if the entropy change (ΔS) occurring during a reversible and isothermal expansion of helium from 2 to 50 liters is 57 J/K.

A) 2 kg
B) 3 g
C) 0.57 g
D) 10 g
Solution:
The entropy change per 1 mole during a reversible and isothermal expansion of an ideal gas can be found using the formula:
$\Delta\overline{S} = R \cdot \ln(V_2/V_1) = 8.314 \cdot \ln(50/2) = 26.76$ J/(K · mol)
The amount of helium substance involved in the process is
$\nu(He) = \Delta S / \Delta\overline{S} = 57/22.76 = 2.5$ mol
mass of helium is equal to
$m(He) = \nu(He) \cdot M(He) = 2.5$ mol · 4 g/mol = **10.0 g**

Task 7. (Topic: Clausis-Clapeyron equation)
The boiling point of acetic acid at 760 mm Hg is 391 K. At what temperature will acetic acid boil if the pressure has been reduced to 300 mm Hg? $\Delta H_{vap}(CH_3COOH) = 24.35$ kJ/mol.
A) 348 K
B) 500 K
C) 91 K
D) 760 K
Solution:
Substitute the known data into the Clausis-Clapeyron equation:
$\ln(P_2/P_1) = \Delta H_{vap}/R \cdot (1/T_1 - 1/T_2)$
$\ln(300/760) = 24350/8.31 \cdot (1/391 - 1/T_2)$
$-0.930 = 2930/391 - 2930/T_2$
$-8.424 = -2930/T_2$
$\mathbf{T_2 = 348\ K}$

Task 8. (Topic: chemical equilibria)

Calculate the equilibrium constant of the reaction $NO + 0.5Cl_2 = NOCl$ at 25 °C if,
ΔG^f_{298}(NO) = 87.58 kJ/mol: ΔG^f_{298}(NOCl) = 39.37 kJ/mol.

A) 0.02
B) $2.85 \cdot 10^8$
C) 500
D) $3.5 \cdot 10^{-9}$
Solution:
$\Delta G^r_{298} = \Delta G^f_{298}$ (NOCl) – ΔG^f_{298}(NO) = 39.37 – 87.58 = – 48.21 kJ/mol
K_p = e^(–ΔG^r_{298}/R/T)= e^(96360/8.31/298) = e^19.5 = $2.85 \cdot 10^8$

Intermediate-level task (5 points maximum)

Task 9. (Topic: Chemical kinetics)
Choose **TWO** correct statements for a reversible reaction following the A↔B mechanism.

A) The concentration of substance A decreases with time and reaches a constant value.
B) The concentration of substance B decreases with time to a zero value.
C) The kinetic equation of this reaction has the form $d[A]/dt = -k_{forw}[A] + k_{rev}[B]$.
D) The equilibrium concentration of substance B will always be greater than the concentration of substance A.
E) The dependence of the concentration of substance B on time is linear.

5 points for 2 correct answers
2 points for 1 correct answer

Advanced-level task (12 points maximum)

Task 10. In 2 liters of distilled water, 0.232 g NaCl were dissolved; the specific conductivity of this solution was found to be 24.6 $mS \cdot m^{-1}$ at 25 °C. Calculate:
1) the molar conductivity of the initial solution;
2) the specific conductivity of NaCl solution if 1 liter of water is added to the initial solution;
3) the molar electrical conductivity of a NaCl solution at infinite dilution and the apparent degree of dissociation of the initial solution in water, if $\Lambda_0(Na^+) = 50.1\ S \cdot mol^{-1} \cdot cm^2$ and $\Lambda_0(Cl^-) = 76.4\ S \cdot mol^{-1} \cdot cm^2$.

Solution:
1) Molar and specific conductivity are related by the equation:

$\Lambda = \frac{\chi}{C}$

Find the molar concentration of NaCl in the initial solution.

C_1 = m(NaCl)/M(NaCl)/V(H_2O) = 0.232/58/2 = **0.002 mol/l**

1 point

Let us convert the concentration to SI units.

C_1 = 2 mol/m^3

Now let us calculate the molar conductivity of the initial solution.

Λ= 24.6 mS·m^{-1} / 2 mol/m^3 = 12.3 mS·mol^{-1}·cm^2 = **0.0123 S·mol^{-1}·m**

3 points

2) For dilute solutions, the specific concentration is directly proportional to the concentration.

$C_2 = C_1\cdot(2+1)/2 = 0.002\cdot 2/(2+1) = 0.00133$ mol/l

$\chi_2 = \chi \cdot \frac{C_2}{C_1}$= (24.6 mS·$m^{-1}$)·0.00133/0.002 = **16.4 mS·m^{-1}**

4 points

3) The molar conductivity of a NaCl solution at infinite dilution is calculated using the Kohlrausch law equation:

$\Lambda_0 = \Lambda_0(Na^+) + \Lambda_0(Cl^-) =$

= 50.1 + 76.4 = 126.5 S·mol^{-1}·cm^2 = **0.01265 S·mol^{-1}·m^2**

2 points

The apparent degree of dissociation is calculated by the formula:

$\alpha_{app} = \frac{\Lambda\cdot 100\%}{\Lambda_0} = \frac{0{,}0123\cdot 100\%}{0{,}01265}$ = **97%**..**2 points**

Section 3. Organic chemistry

Entry-level tasks (each correct answer - 1 point)

Task 11. Choose a disaccharide capable of mutarotation:

1) ethyl-β-cellobioside
2) methyl-α-lactoside
3) maltose
4) ethyl-β-maltoside
5) sucrose

Solution:

Mutarotation is a change in the magnitude of optical rotation of solutions of optically active compounds due to the epimerization of a semi–acetal carbon atom.

Mutarotation is characteristic of monosaccharides reducing disaccharides. Reducing disaccharides (lactose, maltose, cellobiose) have a free semi-acetal hydroxyl group, which preserves the ability to open the cycle. Non-reducing disaccharides (sucrose, trehalose) do not have a hydroxyl group at any anomeric center, as a result, they do not show mutarotation, nor are Glycosides capable of it.

Task 12. When cooled, 3-aminobenzaldehyde interacts with sodium nitrite in the presence of sulfuric acid. When the resulting solution is heated to a standard temperature, it forms

1) 3-hydroxybenzaldehyde.
2) 3-hydroxybenzoic acid.
3) 3-nitrobenzoic acid.
4) 3-aminophenol.
5) 3-aminobenzoic acid.

Solution:

The diazotization reaction is the interaction of aromatic amines with nitric acid to form aromatic diazo compounds. It takes place in the cold, as a rule in the temperature range of 0 to 5ºC.

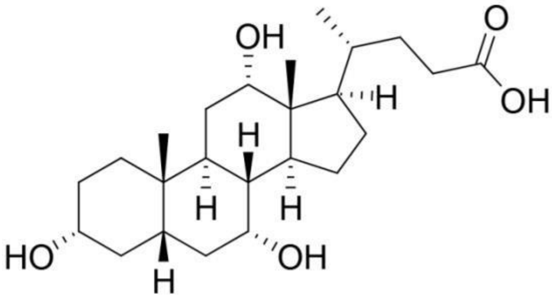
Generally, sodium nitrite ($NaNO_2$) is used in the presence of an excess of inorganic acid for diazotization; diazonium salts are formed by the reaction:

$$RNH_2 + NaNO_2 + 2H_2SO_4 \rightarrow RN{=}N^+\ HSO^-_4 + NaHSO_4 + 2H_2O$$

Diazo compounds are very unstable and decompose after a short time in an aqueous solution, especially when heated with the formation of phenols:

$$RN{=}N^+\ HSO^-_4 + H_2O \rightarrow ROH + N_2 + H_2SO_4$$

Task 13. Which of the statements is NOT true of cholic acid?



cholic acid

1) It forms a blue compound with copper (II) hydroxide.

2) It forms an ester when interacting with ethanol in an acidic environment.

3) It is oxidized by chromium (VI) oxide.

4) It contains 24 carbon atoms.

5) It is a monobasic acid.

Solution:

Cholic acid ($C_{24}H_{40}O_5$) is a monobasic trioxyacid containing one COON group. One of the bile acids, it reacts esterification with alcohols. With careful oxidation with chromium (VI) oxide or chromic acid, it forms dehydrocholic acid ($C_{24}H_{34}O_5$). Cholic acid forms, like starch, a blue compound with iodine.

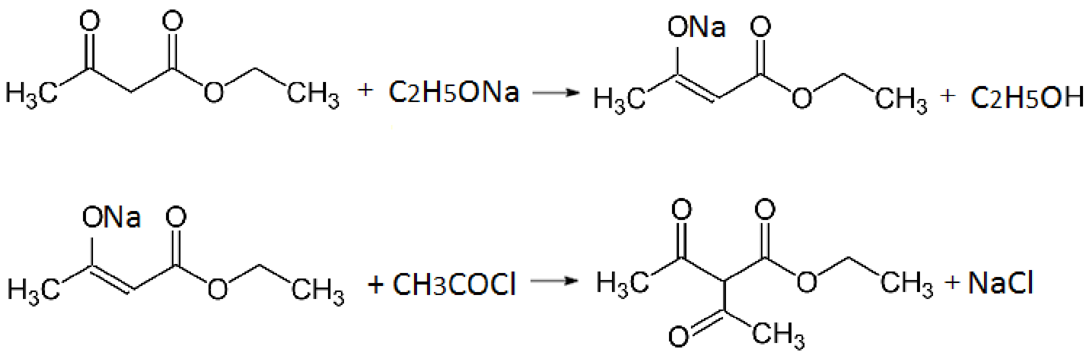
<u>Intermediate-level task (5 points maximum)</u>

Task 14. Fill in the transformation diagram. In the answer, specify the molecular weight of the substance:

$$Aetoaceticester\underset{\rightarrow}{C_2H_5ONa}A\underset{\rightarrow}{CH_3COCl}B$$

Answer 172 g/mol

Solution:



Molecular weight M($C_8H_{12}O_4$) = **172 g/mol**

Substances A and B have been indicated (and / or reactions are recorded): 4 points.

The molecular weight of substance B has been determined: 1 point.

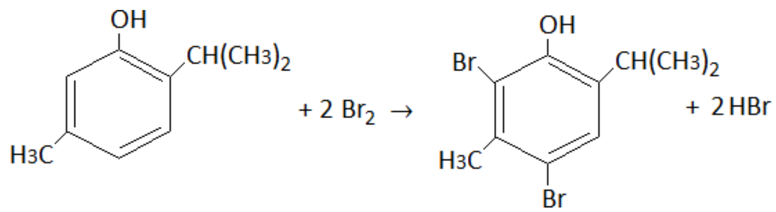
Task 15. Thymol (2-isopropyl-5-methylphenol) is used in medicine as an antiseptic and antimicrobial agent. The content of thymol in the substance is quantified with the help of bromatometric titration as follows: the suspension of the substance weighing 0.500 g is dissolved in a solution of sodium hydroxide in a 100 ml measuring flask; the volume of the solution is brought to the mark with distilled water. For titration, a 10.0 ml sample is taken. It is transferred to a titration flask; an excess of potassium bromide and hydrochloric acid is added (the indicator is methyl orange) and titrated with a standard 0.0167 M solution of potassium bromate until the pink staining disappears. Therefore, a total of 11.93 ml of potassium bromate solution was spent on titration.

Calculate the mass fraction of thymol (in %) in the substance. Expressed your answer in per cent, rounded to the first decimal place.

Answer 89.8

Solution:

$KBrO_3 + 5KBr + 3H_2SO_4 \rightarrow 3Br_2 + 3K_2SO_4 + 3H_2O$



The amount of potassium bromate consumed for titration:

$\nu(KBrO_3)$ = 0.0167 mol/l · 11.93 ml = 0.1993 mmol;

The amount of thymol substance in the titration sample is:

$\nu(C_{10}H_{14}O)$ = 0.1993 mmol · 3/2 =0.2989 mmol

2 points

The thymol mass in the titration sample is:

m $(C_{10}H_{14}O)$ = 150.22 g/mol · 0.2989 mmol = 44.9 mg

1 point

The weight of thymol in the sample:

m $(C_{10}H_{14}O)$ = 44.9 mg · 100/10 = 449 mg = 0.449

1 point

The mass fraction of thymol in the sample:

ω $(C_{10}H_{14}O)$ = (0.449/0.500) · 100% = 89.8%

1 point

Section 4. Analytical chemistry

Entry-level tasks (each correct answer - 1 point)

Task 16. Lead ions are potential toxic, which attaches great importance to developing sensitive methods for their detection and quantification in study samples. Calculate the detection limit for lead (II) ions in a solution if the maximum concentration of lead ions in the solution is $4 \cdot 10^{-6}$ g/ml, and the minimum volume of the test solution is 0.025.

A) 0.05

B) 0.1

C) 0.25

D) 0.40

E) 0.75

Solution:

The detection limit *m* is the smallest mass of the ion possibly determined, which can be unambiguously established by the given reaction according to the given technique in the minimum volume of an extremely dilute solution. It is expressed in mcg.

The limit concentration is the lowest concentration of the detected ion in the analyzed solution at which the ion can be detected by this reaction. It is expressed in g/ml.

$m(Pb^{2+}) = c(lim) \cdot V(min) \cdot 10^6 = 4.0 \cdot 10^{-6} \cdot 0.025 \cdot 10^6 = 0.1$ mcg.

Task 17. Calculate the ionic strength of a solution containing 0.010 mol of barium nitrate and 0.1 mol of sodium chloride in 1 liter of a solution. Choose the correct answer.

A) 0.26

B) 0.13

C) 0.23

D) 0.11

E) 0.14

Solution:

I, the ionic strength of a solution, is defined as half the sum of the products of ion concentrations and the squares of their charges.

$Ba(NO_3)_2 \rightarrow Ba^{2+} + 2NO_3^-$;

$NaCl \rightarrow Na^+ + Cl^-$

$I = 0.5 \cdot (0.01 \cdot 2^2 + 2 \cdot (0.01) \cdot 1^2 + 0.1 \cdot 1^2 + 0.1 \cdot 1^2) = 0.13$

Task 18. 150 ml of 0.200 mol/l methanoic acid solution and 50 ml of 0.400 mol/l potassium hydroxide solution were mixed. Calculate the pH value of the resulting solution. Choose the correct answer.

A) 4.05
B) 3.75
C) 3.25
D) 4.55
E) 4.75

Solution:

When the solutions of methanoic acid and potassium hydroxide are drained in a solution, the reaction is as follows:

$HCOOH + KOH = HCOOK + H_2O$

For the calculation, it is necessary to find out which of the reagents is taken in excess and which is in short supply.

Let us calculate the amount of the substance of methane acid and potassium hydroxide in the initial solutions.

n (HCOOH) = 0.200 * 0.15 = 0.0300 mol
n (KOH) = 0.400 * 0.05 = 0.0200 mol

Potassium hydroxide is taken in short supply, therefore an unreacted weak acid and its salt are present in the solution after the reaction:

n (HCOOH) = 0.0300 – 0.0200 = 0.0100 mol
n (HCOOK) = n (KOH) = 0.0200 mol

A **buffer system** is formed in the solution:

$pH = 3.75 - \lg(0.0100 \cdot V_{sum})/(0.0200 \cdot V_{sum}) = 4.05$

Intermediate-level task

Task 19. (5 points maximum) A yellow transparent solution is analyzed. The following tests have been carried out on individual portions of the solution:

– when a solution of potassium hexacyanoferrate (II) formed a Prussian blue precipitate,
– when a solution of potassium thiocyanate caused blood–red staining,
– when silver nitrate formed a precipitate that completely dissolved in concentrated ammonia.

Select the ions whose presence in the solution ensured the course of these reactions. Write down the reactions.

1) Fe^{3+}
2) Co^{2+}
3) Al^{3+}
4) NO_3^-

5) Cl^-

Solution:

1) Yellow blood salt (potassium hexacyanoferrate(II)) interacts with iron ions () forming a Prussian blue precipitate.

$4Fe^{3+} + 4K_4[Fe(CN)_6] = 4KFe[Fe(CN)_6] + 12K^+$

2) Moreover, iron (III) ions interact with potassium rhodanide (thiocyanate) to form a red iron rhodanide precipitate.

$Fe^{3+} + 3CNS^- = Fe(CNS)_3$

3) Under the action of silver nitrate, a precipitate formed, which completely dissolved in concentrated ammonia.

$Cl^- + Ag+ = AgCl$

$AgCl + 2NH_3 \cdot H_2O = [Ag(NH_3)_2]Cl + 2H_2O$

Solution element	Points
Ions selected from the list	1
$4Fe^{3+} + 4K_4[Fe(CN)_6] = 4KFe[Fe(CN)_6] + 12K^+$	2
$Fe^{3+} + 3CNS^- = Fe(CNS)_3$	
$Cl^- + Ag+ = AgCl$	2
$AgCl + 2NH_3 \cdot H_2O = [Ag(NH_3)_2]Cl + 2H_2O$	
Maximum score	**5**

Task 20. (6 points maximum) Copper sulfate, which is used in medicine as an antiseptic, has an astringent, cauterizing, and erythropoietic local effect. In small doses, it acts as a catalyst accelerating the formation of hemoglobin. Therefore, it is used to treat anemia alongside iron preparations.

A technical sample of copper (II) sulfate pentahydrate weighing 1.85 g is dissolved in water, transferred to a 50.0 ml measuring flask, and brought to the mark with distilled water. Then, 10.0 ml of a 10% potassium iodide solution and 2 ml of a sulfuric acid solution with a concentration of 1 mol / l are added to a 5.0 ml sample of the solution. The flask is covered with glass until the reaction is finished. The resulting mixture is titrated with a solution of sodium thiosulfate with a concentration of 0.25 mol / l to a pale yellow color. Five drops of starch solution are added, and titration is continued until the solution discolors. A total of 2.6 ml of sodium thiosulfate solution is added.

Write the reaction equations and calculate the mass fraction of copper sulfate in the initial sample.

Solution:

1) The reaction equations are written as follows:

$2\,CuSO_4 + 4KI \rightarrow 2CuI + I_2 + 2K_2SO_4$

$I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6$

2) The amount of the sodium thiosulfate substance is:

$\nu\ (Na_2S_2O_3) = 0.25 \cdot 2.6 = 0.65$ mmol

3) The amount of copper(II) sulfate substance is calculated:

$\nu\ (CuSO_4) = \nu\ (Na_2S_2O_3) = 0.65$ mmol (as a unit fraction)

$\nu\ (CuSO_4) = 0.65 \cdot 50/5 = 6.5$ mmol = 0.0065 mol (in the solution)

4) The mass and mass fraction of copper (II) sulfate in the initial sample are:

$m\ (CuSO_4) = 0.0065 \cdot 159.6 = 1.037$ g

$\omega\ (CuSO_4) = 1.037/1.85 = 0.5608$ (56.08 %)

Answer: 0.5608 (56.08 %)

Solution element	Points
Reaction equations has been written	2
The amount of sodium thiosulfate substance has been calculated	2
The amount of copper (II) sulfate substance has been calculated	
The mass fraction of copper (II) sulfate in the initial sample has been determined	2
Maximum score	**6**

Section 5. Solid state chemistry

Entry-level tasks (each correct answer - 1 point)

Task 21. (Topic: densest packing)
A hexagonal densest packing is described by the sequence
A) *ABCDEF*.
B) *ABCABC*.
C) *ABCABA*.
D) *ABABAB*.

Task 22. Calculate the hole mobility of silicon doped with aluminium at a concentration of 10^{-8} atoms, if its electrical conductivity $\varkappa$ = 4.0 $Ohm^{-1} \cdot m^{-1}$. (ρ(Si) = 2.4 g/cm^3).
A) 0.0485 $m^2/(V \cdot s)$
B) 0.5 $m^2/(V \cdot s)$
C) 4 $m^2/(V \cdot s)$
D) 10^{-4} $m^2/(V \cdot s)$
Solution:

$$u = \frac{\chi \cdot M(\mathrm{Si}) \cdot 10^{-6}}{1\text{см}^3 \cdot \rho(\mathrm{Si}) \cdot N_A \cdot 10^{-8} \cdot 1{,}602 \cdot 10^{-19}} = 0.0485\ \mathrm{m^2/(V \cdot s)}$$

Task 23. (Topic: properties of solids and volume structure)
What is the crystal density of NaCl if it crystallises in a cubic lattice with the parameter a = 5.64 Å, and there are 4 formula units per lattice?

A) 10.27 g/cm^3
B) 2.163 g/cm^3
C) 0.564 g/cm^3
D) 7.074 g/cm^3

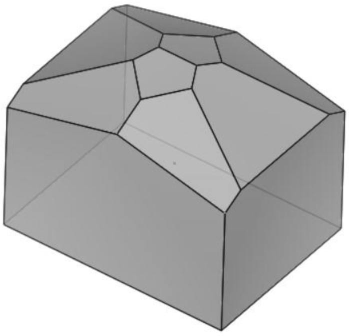
Solution:

$$\rho = \frac{n \cdot M}{N_A \cdot a^3} = \frac{4 \cdot 58.443}{6.023 \cdot 10^{23} \cdot (5.64 \cdot 10^{-8})} = 2.163\ \mathrm{g/cm^3}$$

Intermediate-level task (5 points maximum)

Task 24. (Topic: operations and elements of symmetry)

Choose **TWO** operations of symmetry shown in the figure.



1) second-order symmetry axis

2) fourth-order symmetry axis

3) symmetry plane

4) Center of symmetry

5) axis of inversion of the sixth order

5 points for 2 correct answers

2 points for 1 correct answer

Task 25. (Topic: point defects and the relationship between their concentration and the composition of the atmosphere above the sample)

Choose **TWO** correct statements. To obtain a sample of nickel oxide with anionic vacancies it is necessary to carry out the synthesis

1) in an O_2 atmosphere.

2) in a CO atmosphere.

3) in an O_3 atmosphere.

4) in an H_2 atmosphere.

5) Atmospheric composition does not affect the formation of anionic vacancies.

5 points for 2 correct answers

2 points for 1 correct answer

Section 6. Materials science

Entry-level tasks (each correct answer - 1 point)

Task 26. Which type of indenters is used in the Rockwell method?

A) a steel ball

B) a steel ball and a diamond cone

C) a diamond pyramid

D) a steel ball and a diamond pyramid

Task 27. Which types of Bravais lattices can exist in the cubic syngony?

A) primitive, body-centered, face-centered

B) primitive, body-centered

C) primitive, base-centered

D) primitive, face-centered

Task 28. A 10.0 mm long sample of dentine dental ceramic was uniformly fired. Determine the linear shrinkage of the sample during firing (in %) if the length of the fired sample was 8.7 mm.

A) 10

B) 13

C) 15

D) 17

Intermediate-level task (5 points maximum)

Task 29. A cylinder-shaped sample of hot curing acrylic base plastic with a diameter of 50 mm and a thickness of 5 mm was kept in distilled water at a temperature of 370 °C for 170 hours and weighed. The mass of the sample was 11.579 g. After the complete drying of the sample in the desiccator, the mass reduced to 11.365 g. Determine the water absorption (W_B) of the polymer (in µg/mm3, round your answer to an integer) if $W_B = \square m/V$.

Answer: 22

Advanced-level task (worth 10 points)

Task 30. The initial length of the sample is 10 mm, and the initial diameter is 3 mm. After stretching, the diameter of the sample decreased to 2 mm. Determine the final length of the sample. The law of volume constancy is written as $F_0 l_0 = F_e l_e$, *where* F_0 is the initial cross-sectional area of the sample, F_κ is the final (post-testing) sample cross-sectional area, l_0 is the initial length of the sample, and l_e is the length of the sample at the end of testing.

The F_0 of the cylinder-shaped sample = $(\pi \times d_0^2)/4 = (3.14 \times 3^2)/2 = 14.13$ mm^2

The $F_к$ of the cylinder-shaped sample = $(\pi \times d_к^2)/4 = (3.14 \times 2^2)/2 = 6.28$ mm^2

$F_0 l_0 = F_e l_e \Rightarrow l_e = (F_0 l_0) / F_e = (14.13 \times 10)/6.28 = 22.5$ mm

Answer: l_e= 22.5 mm.

The law of volume constancy has been written down ($F_0 l_0 = F_e l_e$): 5 points;

The formula for calculating the cross-sectional area of the cylinder-shaped sample has been written down ($F_0 = (\pi \times d_0^2)/4$): 3 points;

The substitution of numerical values into formulas is worth 1 point;

The determination of the final length into the sample is worth 1 point.